REPORT RESUMES

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INSTITUTIONS WHICH EDUCATE TECHNICIANS SHOULD ALSO PROVIDE PRETECHNICAL POST HIGH SCHOOL PROGRAMS TO HELP UNDERPREPARED STUDENTS MEET ENTRY REQUIREMENTS OF TECHNICAL PROGRAMS. IN ADDITION TO HIGH SCHOOL DROPOUTS, SUCH STUDENTS INCLUDE HIGH SCHOOL GRADUATES (1) WHO HAVE NOT STUDIED THE NECESSARY COURSES, (2) WHO HAVE MOTIVATION TOWARD MECHANICAL OR SCIENTIFIC PURSUITS BUT HAVE NOT MASTERED ORGANIZED BASIC STUDIES, AND (3) WHOSE SCHOLARSHIP HAS SUFFERED BECAUSE OF THEIR EMPLOYMENT WHILE IN HIGH SCHOOL. SUCCESS OF PRETECHNICAL PROGRAMS DEPENDS UPON CAREFUL RECRUITMENT AND SCREENING OF STUDENTS, A COMPETENT FACULTY, AND ADEQUATE COUNSELING AND GUIDANCE SERVICES. THE LIBRARY MUST BE ADEQUATE TO SUPPORT THE PROGRAM, ALLOW FOR PROGRAMED LEARNING, AND PROVIDE A STUDY SKILLS LIBRARY. AN EQUIPMENT LIST AND COST SUMMARY FOR SUCH A FACILITY HAS BEEN PREPARED, AS HAVE COURSE OUTLINES IN STUDY SKILLS, TWO 1-SEMESTER MATHEMATICS COURSES, TWO 1-SEMESTER PHYSICS COURSES, A 2-SEMESTER CHEMISTRY COURSE, AND A 1-SEMESTER BIOLOGY COURSE. THE DOCUMENT INCLUDES A BIBLIOGRAPHY. THIS DOCUMENT IS ALSO AVAILABLE AS CATALOG NO. FS 5.280--80049 FOR $.45 FROM THE SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402. (WO)

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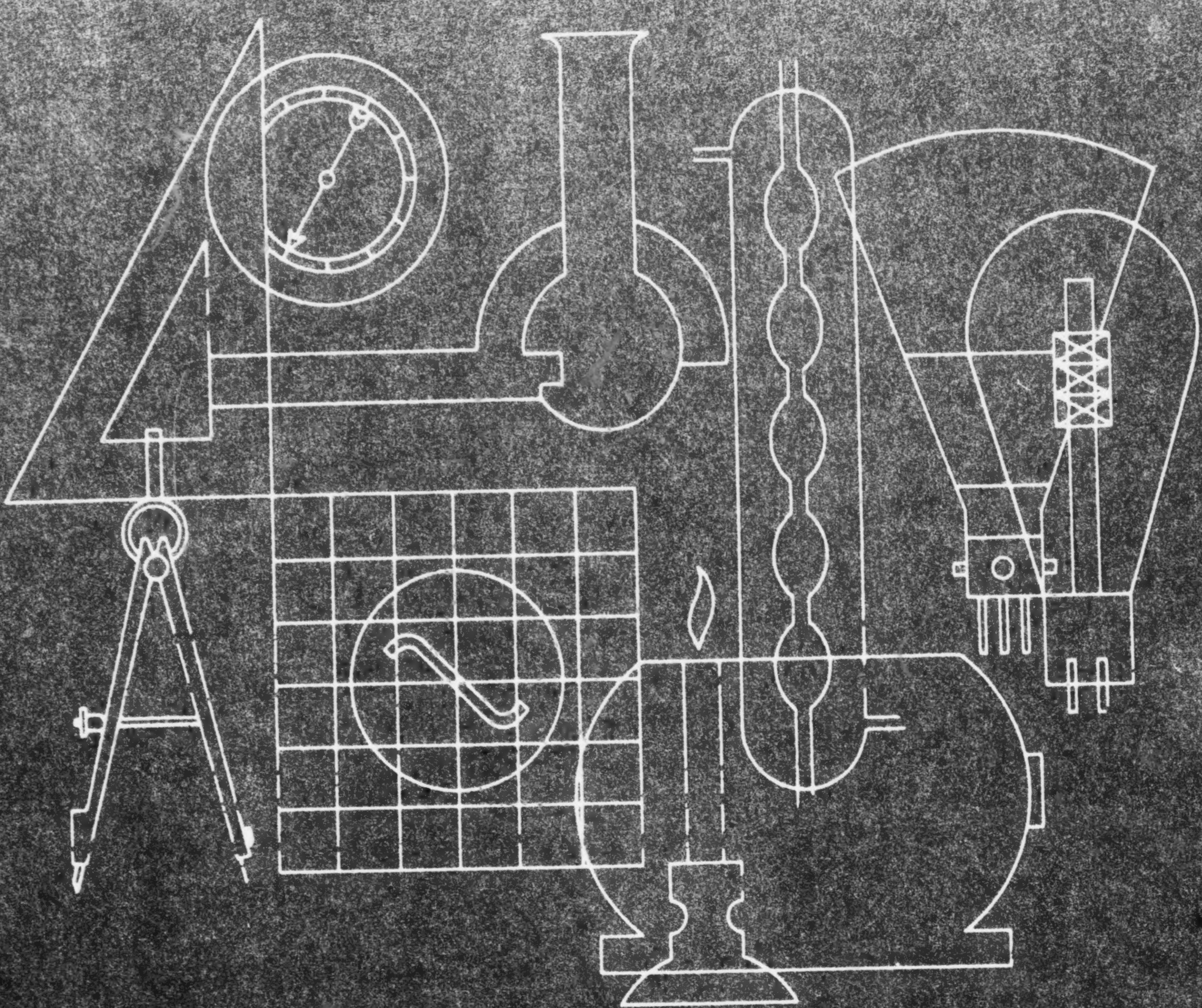
Pretechnical Post High School Programs

A Suggested Guide



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Technical Education Program Series No. 12

PRETECHNICAL POST HIGH SCHOOL PROGRAMS

A Suggested Guide

UNIVERSITY OF CA
LOS ANGELES

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FOREWORD

This is a suggested program of remedial instruction for post high school students whose scholastic preparation does not meet the required level to insure their success in a technical program. Many students who graduated or who left high school near graduation have not had the scholastic preparation required to enter a rigorous technical curriculum although they are highly motivated and potentially promising student technicians. Without some remedial instruction most of these students would fail in the high quality technical program of their choice. If the technical program is lowered to their entering scholastic level it cannot graduate competent and skilled technicians. Programs such as the one suggested are needed to provide promising but underprepared students the opportunity to become technicians. With proper preparation such students can help fill the shortage of highly trained technicians.

The guide suggests course outlines with examples of textbooks and references, a sequence of educational procedure, and a special learning laboratory layout with equipment and cost and discusses faculty, student services, and library facilities. It has been prepared to assist school administrators, advisory committees, supervisors, and teachers in planning and developing new remedial programs.

This guide was developed by technical education specialists in the Occupations Section of the State Vocational Services Branch, Divisions of Vocational and Technical Education, U.S. Office of Education. The basic materials were prepared by the State University of New York Agricultural and Technical College at Alfred, New York, under contract with the Office of Education. The final draft was prepared by Walter J. Brooking, assisted by Alexander C. Ducat, under the direction of Robert M. Knoebel, Acting Assistant Director, Occupation Section, and Earl M. Bowler and staff, Program Services Branch.

Many useful suggestions were received from special consultants and from administrators and teachers in schools of technology. Although all suggestions could not be incorporated, each was considered carefully as it related to the publication's intended use. It should not be inferred however that the document is completely endorsed by any one institution, agency, or person.

Grant Venn
Associate Commissioner
for Adult, Vocational, and
Library Programs

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CONTENTS

Page

Foreword ... iii

Acknowledgements ... iv

Technology and Pretechnical Programs ... 1
  The Increasing Need for Technicians ... 3
  Kinds of Technicians ... 3

Prerequisites for Technical Curriculums ... 5

The Need for Pretechnical Programs ... 9

Program Plans ... 13
  Objectives of the Programs ... 15
  Advantages of Full-Time Study ... 16

Special Administrative Considerations ... 18
  Federal Support ... 19
  Advisory Committees and Services ... 19
  Student Selection ... 20
  Faculty ... 22
  Student Counseling, Guidance, and Advisory Services ... 24

Physical Facilities and Their Cost ... 26
  Equipment Selection and Acquisition—General Considerations ... 26
  The Library to Support the Program ... 27
  Programed Learning Outside Study Area ... 29
  The Study Skills Laboratory ... 30
  Cost Summary ... 33

Course Outlines ... 35
  Study Skills ... 35
  Preparatory Communication Skills I and II ... 38
  Preparatory Mathematics I ... 39
  Preparatory Mathematics II ... 42
  Preparatory Physics I ... 43
  Preparatory Physics II ... 45
  Preparatory Chemistry I and II ... 49
  Preparatory Biological Science ... 52

Bibliography ... 56

Appendixes

A. Examples of Chemistry Laboratory Exercises in Preparatory Chemistry for Biological Science Based Curriculums ... 60
B. A Typical Laboratory Experiment for Preparatory Biological Science ... 64
C. Audiovisual Materials and References ... 65

TECHNOLOGY AND PRETECHNICAL PROGRAMS

Pretechnical post high school programs offer students an opportunity to overcome their scholastic deficiencies and to meet requirements for entering a technical program. Many high school graduates and many students who left high school near graduation lack one or more of the courses which are essential for entry into a high quality technician program. Others, through review of some of their high school subjects, can raise their capabilities and increase their chances of successfully completing a rigorous technical curriculum. Without some preliminary study many students cannot be accepted into high quality technical programs because if permitted to enter they usually fail. To serve the needs of such students, institutions are providing pretechnical courses of study as a part of the total technician education program.

Pretechnical programs can effectively increase the number of students available to enter technician education programs and can thus contribute significantly to the total number of technicians who graduate each year and enter the labor force.

Figure 1 shows the relationship between pretechnical courses of study and technical curriculums. Underprepared students enroll as technicians and study the pretechnical courses which

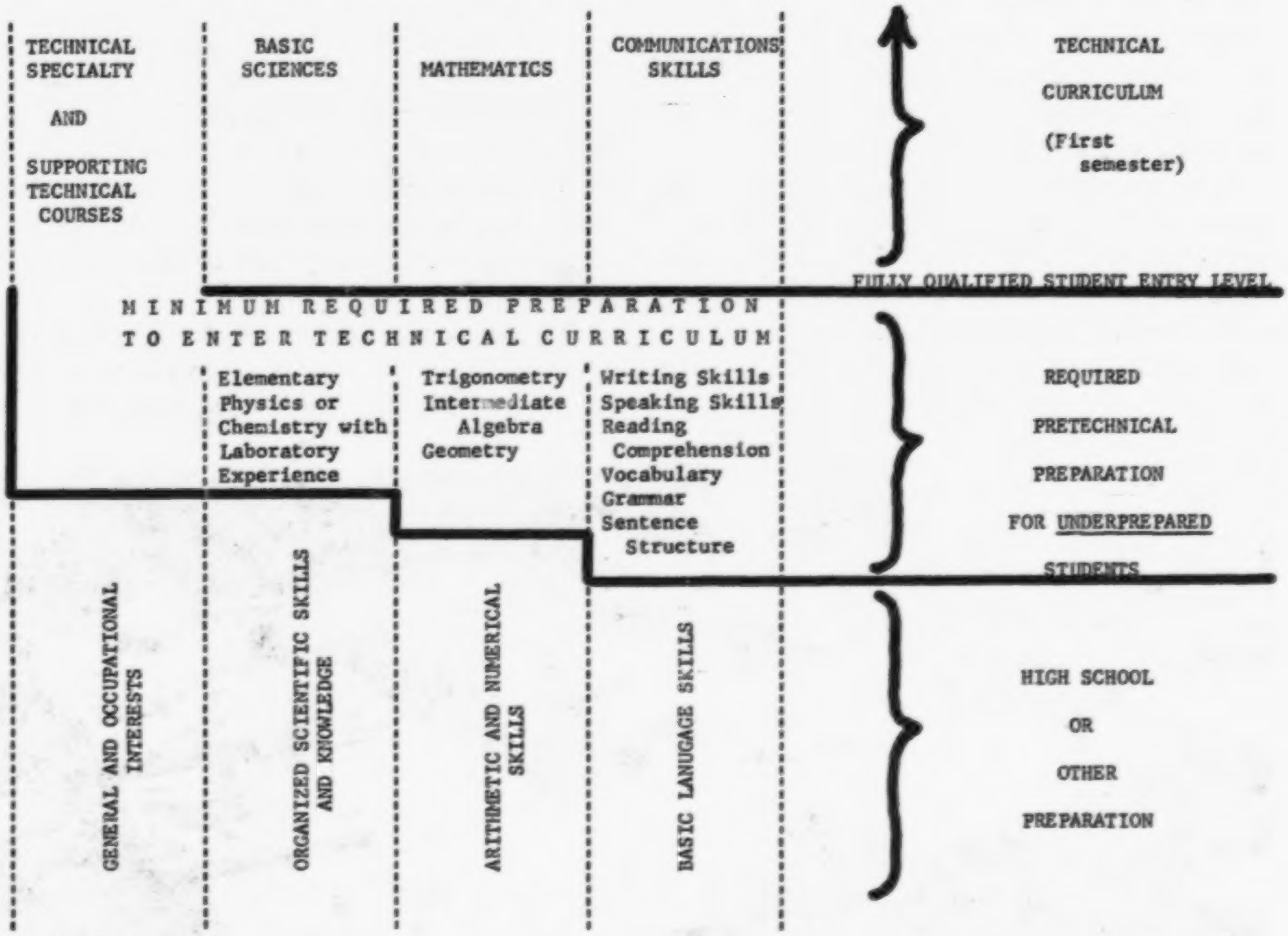
TECHNICAL SPECIALTY AND SUPPORTING TECHNICAL COURSES
BASIC SCIENCES
MATHEMATICS
COMMUNICATIONS SKILLS
TECHNICAL CURRICULUM (First semester)
FULLY QUALIFIED STUDENT ENTRY LEVEL
MINIMUM REQUIRED PREPARATION TO ENTER TECHNICAL CURRICULUM
Elementary Physics or Chemistry with Laboratory Experience
Trigonometry Intermediate Algebra Geometry
Writing Skills Speaking Skills Reading Comprehension Vocabulary Grammar Sentence Structure
REQUIRED PRETECHNICAL PREPARATION FOR UNDERPREPARED STUDENTS
GENERAL AND OCCUPATIONAL INTERESTS
ORGANIZED SCIENTIFIC SKILLS AND KNOWLEDGE
ARITHMETIC AND NUMERICAL SKILLS
BASIC LANUGAGE SKILLS
HIGH SCHOOL OR OTHER PREPARATION

FIGURE 1. Pretechnical programs permit underprepared student technicians to raise their scholastic capabilities in subjects which need strengthening to meet normal entry requirements while they begin elementary courses in their technical field.

will increase their scholastic skills to meet the full entrance requirements. It should be remembered that not all pretechnical students will require assistance in all the subject areas shown. From the onset of their pretechnical study they are enrolled in the beginning courses of their technical specialty, such as elementary laboratory or shop work, mechanical drawing, drafting, or graphic representation courses related to their specialty but not greatly dependent on mathematics or basic science.

The objective of pretechnical courses is to enable students to acquire the necessary understanding and skills in one or more subjects. Communications skills (reading, writing, spelling, grammar, punctuation, speaking, listening, and language comprehension), mathematics, physics, chemistry, or biology at levels equivalent to a good high school program are required to enter technical specialty courses in an occupational curriculum. For example, the student may have to complete courses in algebra, geometry, and physics before taking the first mathematics or physics courses in a technical curriculum. If he lacks algebra and physics when he enrolls in the institution, satisfactory completion of pretechnical algebra and physics will prepare him to undertake the mathematics in a particular technology. While he is enrolled in the pretechnical courses he can also be studying elementary technical subjects.

If a student is deficient in algebra and physics and applies to enter a technical program, he cannot be accepted until the deficiency is removed. Many students either cannot find the opportunity to remove such scholastic deficiencies or do not take advantage of it.

Pretechnical post high school programs should be the responsibility of institutions which educate technicians. Schools which provide technical education can best design pretechnical programs and can make such programs an integral part of each student technician's occupational objectives. This is a compelling reason *for providing post high school pretechnical programs in the post secondary institution* where facilities, teaching capability and incentive, and an intimate understanding of specific requirements for the student's technical program are all parts of the institution's daily preoccupation.

Some students who are beginning a technical program will require two semesters to complete the equivalent of high school communications, mathematics, or science courses. Others may be able to complete their pretechnical courses in only one semester, or for very special cases in a summer session.

Pretechnical post high school programs should be organized for two semesters. Most students needing additional mathematics or physics require a year of study; sometimes they may also need to strengthen study and communications skills. Courses could be made available for students who require only a part of one semester of remedial study.

The pretechnical courses required by each student are scheduled according to his needs, and the rest of his schedule is filled with courses in

Figure 2. Elementary courses in drawing or graphic representation are examples of technical courses where both fully qualified and underprepared (pretechnical) student technicians can begin their technical study.

the technical curriculum of his choice. Details of scheduling are discussed later under *Program Plans.*

The first full year of a pretechnical student's schedule after he completes the pretechnical semesters is usually one or more courses less than the normal full first semester load in the technology. This is because he studies introductory courses in his technical specialty during the first and second semester of the pretechnical program. The somewhat reduced scholastic load for pretechnical students has been found beneficial. It allows them to become exposed gradually to the full rigor of a technical curriculum. The lighter load helps the student attain success in all his courses. Scholastic success increases the student's confidence in himself and strengthens his motivation toward his ultimate occupational goal.

The Increasing Need for Technicians

Highly skilled technicians are increasingly needed to cope with the demands of the developing, sophisticated technologies in the Nation. Technicians are persons with scientific knowledge and competencies who support the work of professional scientists or engineers in some recognized branch of science. They are usually educated in rigorous 2-year post secondary programs which provide the knowledge, skills, and attitudes required for work in a specific field of applied science. Technicians perform complex tasks and must be highly trained to accept important responsibilities. Their training must be based on solid preparation before they enter a technical curriculum, otherwise they cannot attain the understanding, special skills, and knowledge which their work will require.

Highly skilled technicians are becoming an increasingly essential part of the scientific and management team in modern scientific research, development, production, and services in all fields of applied science. The team is comprised of professional scientists; specially trained technicians; supervisors; and skill production, laboratory, or service workers. At present the ratio of technicians to professional physical scientists or engineers is usually less than 1 to 1, but the trend seems to be toward 2 or more for each engineer or professional physical scientist. There should probably be as many as 6 to 10 technicians for every medical doctor or professional researcher in the health field and 4 or 5 for each professional biological or agricultural scientist. In addition, the managers and operators of the Nation's farms must increasingly have preparation equivalent to that of a technician.

Our scientific knowledge now doubles every 10 to 20 years. This explosion rate has caused so many changes in scientific education that the recently graduated professional scientist, specialized physician, or engineer often has had limited laboratory experience. He functions more as a theorist, diagnostician, interpreter, inventor, or administrator than he did in the past and delegates many of the laboratory duties of his scientific work to skilled assistants and other members of the scientific team. Highly skilled technicians are therefore using the skills of applied laboratory knowledge and practices which once belonged only to the professional scientist. It is estimated that over 200,000 technicians of all kinds are needed each year. New kinds of technicians are also increasingly demanded. The total number of technicians graduating from preparatory programs each year is *less than half the number required to meet the Nation's needs.*

Technician education programs are devoted to producing highly specialized workers capable of performing many special, skilled tasks. They have almost reached the professional level in education, attitude, and competence. Such programs require rigorous study of scientific principles and supporting mathematics plus intensive laboratory-oriented instruction. Since the objective of this type of program is to prepare the student for gainful employment as a technician, the program should provide opportunities for him to acquire (1) the knowledge of applied scientific principles and their application to the hardware, processes, procedures, services, techniques, and materials in modern measuring and control devices, and (2) the ability to communicate with the professional engineer or scientist and to act as his delegate and assistant.

Kinds of Technicians

There are as many kinds of technicians as there are kinds of professional scientists. Various descriptive names have been given to technicians, but almost all may be placed within the following general classifications:

- *Physical Science and Related Engineering Technologies*
  - Aeronautical and aerospace
  - Architectural and building construction
  - Civil (highway and structural)
  - Chemical
  - Electrical and/or electronic
  - Electro-mechanical
  - Instrumentation
  - Mechanical design or production (including heating, air conditioning and refrigeration, plastics, and welding)
  - Metallurgical (including ceramic)
  - Mining (including earth sciences)
  - Nuclear
  - Oceanographic (physical)
  - Printing (including photography and graphic arts)
  - Radiological (physical)
  - Other
- *Biological Science Technologies*
  - Health and related technologies
    - Dental hygienist
    - Dental laboratory
    - Inhallation therapist
    - Occupational and rehabilitation therapist
    - Medical laboratory
    - Nursing (2-year diploma or certificate)
    - Radiological (including x-ray)
    - Other
  - Agricultural and related technologies
    - Livestock production (cattle, sheep, swine, horses)
    - Dairy production
    - Poultry
    - Other specialized animal science
    - Diversified farm production
    - Farm crop production (field crops, forage, orchards and vineyards, intensive vegetable culture)
    - Ornamental horticulture (nursery, floriculture, turf management, arboriculture. landscape development)
    - Grain, feed, seed, and farm supply services
    - Forestry
    - Conservation, recreation, and wildlife
    - Soil science, reclamation, and conservation
    - Other
- *Combined Physical and Biological Technologies*
  - Agricultural equipment (farm machines and mechanization systems)
  - Dairy products processing
  - Food processing (canning, drying, freezing, freeze drying, etc.)
  - Bio-medical (hospital and research) mechanisms
  - Oceanographic (fishing, mariculture, and other biological fields)
  - Sanitation and environmental control (water and wastewater, solid waste, atmosphere)
  - Scientific data processing
  - Other

While this publication concerns itself primarily with technicians, it is important to recognize that there is a whole spectrum of specialized occupations which support and assist professional management and the technician is only one of these. The occupational equivalent of the technician is required in the financial and administrative management sector of business and in the marketing, transportation, and servicing of the products of industry. The education of men and women to support specialized management is a part of the task of our local educational institutions. Their programs must meet and serve the supportive personnel demands of professional leaders employed in many fields. Programs for educating such occupational specialists may be offered in institutions which also educate technicians. The shortage of qualified applicants for all of these programs is a major problem.

PREREQUISITES FOR TECHNICAL CURRICULUMS

Preparing functionally competent technicians for any of the foregoing broad technical fields makes three major demands upon technical training: (1) The training should equip the graduate to take an entry job in which he will be productive; (2) it should enable him to advance to positions of increasing responsibility after a reasonable amount of experience; and (3) it should provide a comprehensive foundation to support further study within the graduate's field of technology. Technical curriculums are designed to meet these three requirements.

A 2-year technology program has certain characteristics which influence the content and organization of the curriculum. Some of these are imposed by the occupations the graduates will enter; some, by the prerequisite special courses that enable students to grasp the specialized information of advanced technology courses; and others, by the technical principles and related practical applications which must be taught in the limited time available. All require that students bring to the program a minimum preparation—including comprehension and knowledge of underlying subject areas and related skills including laboratory experience, basic study habits, and language competencies.

The scholastic achievement required to enter a high quality technician education program is not greatly different from that required to enter a baccalaureate degree program. In fact, technician programs are more restrictive than some baccalaureate degree programs because of the mathematics and science required for entry.

Prerequisite preparation to enter technician education programs is published as a part of the description of programs in catalogs from institutions offering technical curriculums. Typical prerequisites for curriculums in either physical science or biological-based technologies include: graduation from high school or the equivalent; two years of mathematics including algebra, geometry, and intermediate algebra or trigonometry; one year of physics *or* one year of chemistry; in some cases a year of biology; and competence in writing, speaking, and reading (usually requiring three to four units of English).

The requirements for entering the physical sciences and related engineering technologies usually emphasize mathematics and physics heavily. The following examples are representative:

Civil Technology, Highway and Structural Options

This curriculum is intended for high school graduates who have particular abilities and interests. In general, students entering the program should have completed 1½ years of algebra, 1 year of geometry, and 1 year of physical science, preferably physics. It should be recognized that the ability levels of those who do or do not meet these general requirements will vary greatly and that some students may have to take refresher courses in mathematics or English to make satisfactory progress.[1]

Chemical Technology

This curriculum is designed primarily for high school graduates who have particular abilities and interests. In general, students entering the program should have completed the equivalent of 1 year of algebra, 1 year of geometry, and 1 year of physical science in their high school program. It should be recognized that the ability levels of those who do, and those who do not, meet these general requirements will vary greatly and that some students may have to take refresher courses in mathematics or English to make satisfactory progress in the program.[2]

Instrumentation Technology

The curriculum is designed for high school graduates who have particular abilities and interests. In general, students entering the program should have completed 2 years of high school mathematics including simultaneous linear equations, exponentials, and radicals; and 1 year of physics, or the equivalent. The ability levels of those who do, and those who do not, meet these general requirements will vary greatly; some students may have to take refresher courses in mathematics, science, or English to make satisfactory

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[1] U.S. Department of Health, Education, and Welfare. Office of Education. *Civil Technology, Highway and Structural Options—A Suggested 2-Year Post High School Curriculum.* (OE-80041) p. 4

[2] ———. *Chemical Technology—A Suggested 2-Year Post High School Curriculum.* (OE-80031) p. 4

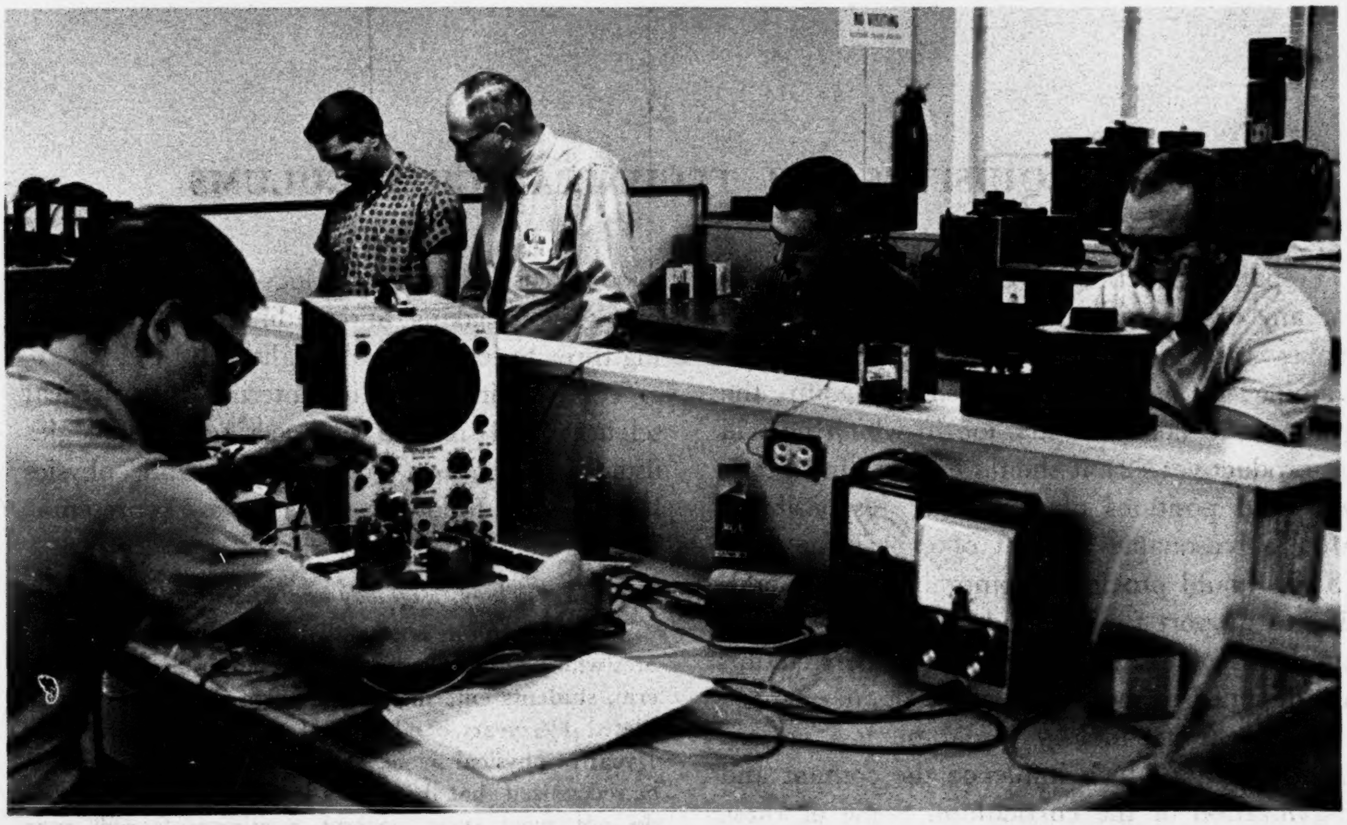

Figure 3. Elementary physics and 2 or more years of high school mathematics must be mastered before student technicians such as these can begin the first semester study of the advanced underlying principles needed for successful completion of their technial curriculums.

progress in the program. Major deficiencies in mathematics or science should be remedied before the student begins formal classes.[3]

The American Society for Engineering Education makes the following statement:

If an effective engineering technology curriculum hinges greatly upon the quality of its faculty, it hinges perhaps even more greatly upon the quality of its incoming students. If the students' high school backgrounds are inadequate, instructors will tend to adjust their course material to these inadequacies. The inevitable result will be that the courses will lose the depth and scope implied in the catalogue and faculty capabilities will not be fully utilized. Any discussion of academic standards, therefore, must be preceded by a statement on admission requirements and student selection.

Admission Requirements

A modern engineering technology curriculum will be based on the assumption that incoming students have been graduated from an accredited secondary school or have had the equivalent education (substantiated by the method recognized in their state). It goes almost without saying that the student should also exhibit some evidence of sufficient ability and the necessary aptitudes for satisfactory achievement in the curriculum. Mere possession of a high school diploma does not, of itself, guarantee sufficient background.

The Committee believes, therefore, that a satisfactory engineering technology program should be based upon the following minimum secondary school units:

(a) Three units of English. The student should at least have been exposed to the rudiments of communication skills.

(b) Two units of mathematics, one of which is in algebra and the other in plane geometry (or the equivalent of these in integrated modern mathematics). The Committee strongly suggests that, in addition to these minimum units, intermediate algebra and trigonometry are desirable.

(c) One unit of physical science with laboratory. Because of the nature of engineering technology it is desirable that wherever possible this unit be in physics or chemistry.

The student should have acquired this minimum background before entering the engineering technology program itself. An institution which admits students with less than these minimum high school units must be prepared to offer a longer program or an acceptable noncredit pre-technical or remedial program.[4]

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[3] ———. *Instrumentation Technology—A Suggested 2-Year Post High School Curriculum.* (OE-80033) p. 5

[4] American Society for Engineering Education. *Characteristics of Excellence in Engineering Technology Education.* p. 19.

The prerequisites for technologies based on biological sciences (agriculture or health related fields) are similar to those for physical science technologies, except that chemistry is required instead of physics and sometimes biology is also required. The following statement of entrance requirements at the State University Agricultural and Technical College at Farmingdale, New York, includes examples which are illustrative:

ADMISSIONS TO THIS COLLEGE and to all other colleges of the State University of New York are based on the academic qualifications of the respective applicants, and are made without regard to the race, color, creed, or national origin of individuals.

1. Applicants must be graduates of approved four year high schools, or hold a high school equivalency diploma.
2. Applicants must be of good character.
3. Applicants must submit evidence of satisfactory health in advance of registration.
4. Applicants must have completed satisfactorily at least 16 units of high school credit, which *should include* the following:

Advertising Art and Design

Art	2	units

Agriculture, Biological Technology, Food Technology and Ornamental Horticulture

Mathematics	2	units (Algebra and Geometry)
Science	2	units (Biology and Chemistry recommended)

Business Administration and Secretarial Science—Industrial

Mathematics	2	units (Algebra and Geometry)

Chemical Technology

Mathematics	2½	units (Including Intermediate Algebra)

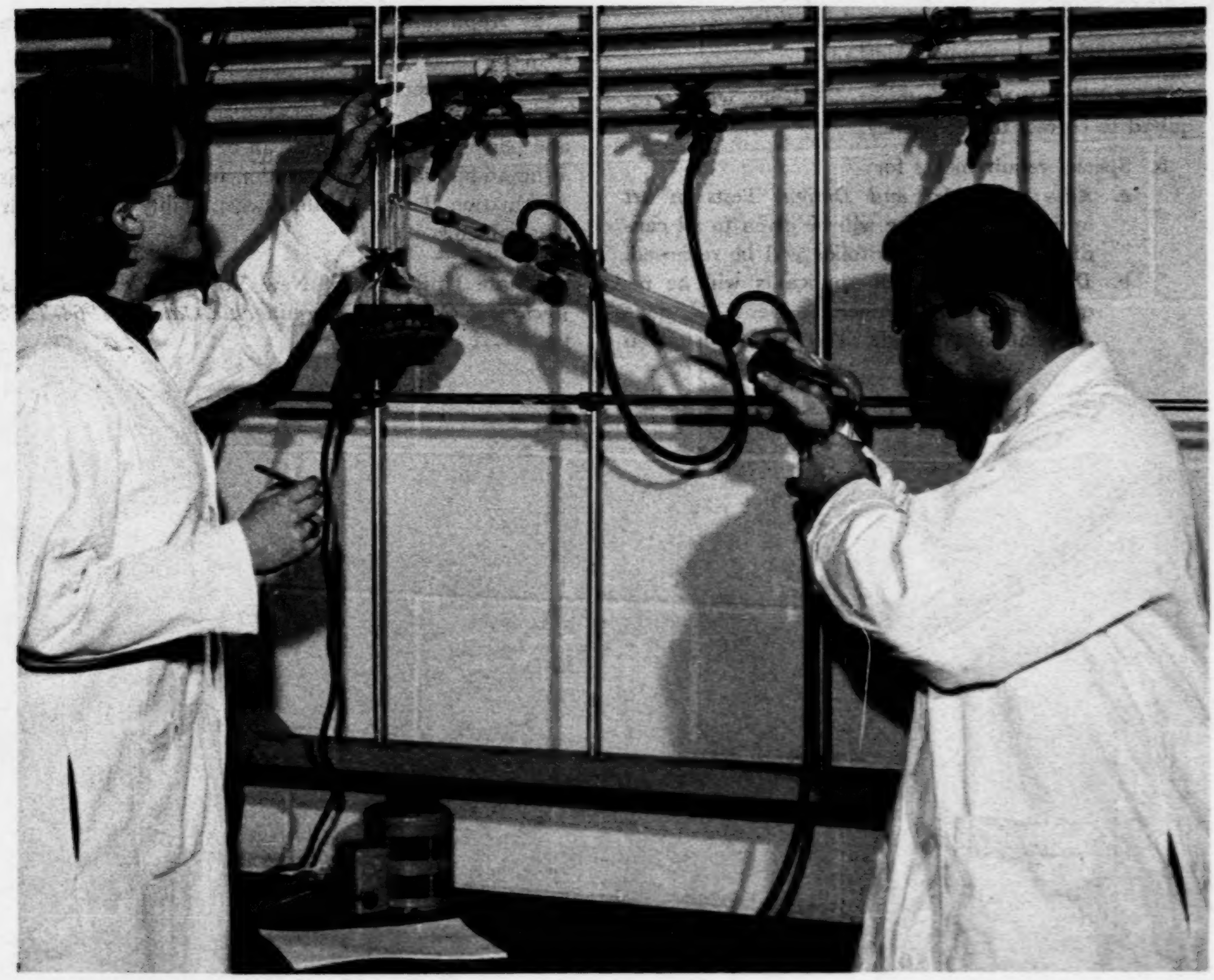

FIGURE 4. Elementary understanding of chemistry and related mathematics is a prerequisite for successful entry to the first semester of technical curriculums in biological science based technologies in agriulture and in health related ocupations.

Physics	1	unit
Chemistry	1	unit

Dental Hygiene

Science	2	units (Biology and Chemistry)

Engineering Science

Mathematics	3½	units (Including Advanced Algebra)
Physics	1	unit

Engineering Technologies (Including Air Conditioning, Civil, Construction, Electrical, Mechanical Power, Mechanical, and Photographic Equipment) and *Aircraft Operations*

Mathematics	2½	units (Including Intermediate Algebra)
Physics	1	unit

Nursing

Mathematics	1	unit (Algebra)
Science	2	units (Biology and Chemistry recommended)

Secretarial Science—Advertising

Mathematics	1	unit (Algebra)

5. Applicants with a subject deficiency will be required to correct the deficiency.

6. Special requirements for:
   a. *Advertising Art and Design.* Tests in art aptitude and ability will be given to all candidates. Student portfolios will be reviewed.
   b. *Dental Hygiene.* All applicants will be required to take the American Dental Hygiene Association Aptitude Test which is given twice yearly at designated places. Further information will be sent upon request for application.

7. Applicants are required to take the New York State Regents Scholarship Examination or the State University Admissions Examination. The Regents Scholarship Examination is given in all high schools each year, usually in October. Applicants should apply for this test through their high school. Students who do not take the Regents Scholarship Examination must take the State University Admissions Examination which will be offered on the campuses of State University units at later dates. Information concerning the State University Admissions Examination is included with the application forms.

Although the results of the tests are considered in selecting students, they are used mainly for guidance purposes. Additional tests may be required. Weaknesses disclosed are scrutinized, and remedial programs, where necessary, are recommended. Evidence of serious deficiencies may have a bearing on acceptance of the applicant.

8. Applicants may be requested to appear for a personal interview.

Scholastic record, extra-curricular activities, out-of-school experiences, health, physical ability, test results, and personal interview may all be considered in evaluating an applicant's preparation for college. From this information the candidate's acceptability is ultimately determined.[5]

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[5] State University of New York. *Agricultural and Technical College at Farmingdale Catalog 1964–1966* pp. 31-32.

THE NEED FOR PRETECHNICAL PROGRAMS

The academic requirements for entering a high quality technical program are practically the same as those for science or engineering baccalaureate degree programs. The number of qualified high school graduates who want to become engineers, scientists, or technicians is not sufficient to satisfy the personal needs of all. Certainly anyone who aspires to a baccalaureate program should be encouraged to work toward that goal.

The impact of technological advances and the replacement of human labor by machines and automation require a larger and larger percentage of the Nation's work force to obtain education which prepares them for more technical employment. The demand for highly skilled technicians and similar specialized supportive employees increases each year; thousands of technician jobs go unfilled while thousands of unskilled or untrained workers seek employment.

Pretechnical programs make it possible for more students to prepare to enter technician training programs. First, they permit able students to overcome deficiencies in their educational preparation and successfully prepare for employment as technicians; this results in greater utilization of individual talents and energies. Secondly, they increase the total number of students who are qualified to enter high quality technician programs, which helps solve a serious problem of student recruitment for many institutions. Thirdly, pretechnical programs provide more and better educated technicians for the future labor force. This will help alleviate a serious present and future shortage of greatly needed persons.

A consideration of some of the characteristics of the post high school student population follows. It is important for school administrators, parents, students, employers, and the general public to recognize the size of this group whose members have special needs. The potential value and service which a pretechnical post high school program can offer to the students, to the school, and to employers who need more and better educated technicians must be clarified.

Many of the Nation's youths whose intelligence and interests make them capable of mastering the curriculum required to become highly skilled technicians have underdeveloped scholastic skills. This is true for several reasons: late maturity, underdeveloped interest in organized study, consuming interest in work or hobbies and other activities, or lack of opportunity to develop scholastic skills.

Many students have not studied the required courses in science or mathematics because:

1. They did not know they needed them.
2. They did not realize the courses were important until it was too late to study them in high school.
3. They considered the courses unusually difficult and avoided them.
4. They didn't need them for the career objective for which they were preparing in high school.
5. The schools they attended didn't offer the courses, or offered them in a schedule which made it impossible for the students to take them.

Students with underdeveloped scholastic skills are unable to enroll in college level technician programs because they cannot qualify academically. Pretechnical post high school programs are needed to help many post high school students develop scholastic skills or to give them the courses they did not study in high school. With these they may enter technician or other specialized occupational programs at the college level. At present, only 3 out of every 10 students who enter elementary school later enroll in collegiate programs, and then only 2 of them graduate. Approximately 4 out of 10 high school graduates considered to be qualified to enter collegiate programs do not do so. Many of these students may want to become technicians but simply have not studied enough mathematics or science to permit them to enter a high quality technical program in the field of their choice.

As indicated before, high school graduates with an average or above average scholastic standing who have taken all of the prerequisite courses make up the population group from which students for technical programs may be drawn. However, in many localities there is a large population of promising potential technical students who do not have all of the prerequisites for entering technical programs.

The variety of differences among such students is endless; but examples of some groups with similar characteristics are:

A. High school graduates who have not studied all of the required subjects.

B. High school graduates with high motivation toward mechanical or scientific activities (ham radio, photography, hot rod automobiles, livestock or animals, etc.) who, because of a consuming interest in such activities, have not concentrated on language, mathematics, or organized science.

C. High school graduates who have spent a large proportion of their time during high school years in out-of-school employment causing their scholastic record to reflect disproportionately low accomplishment when considered in the light of the student's total high school *employment* and *academic* load.

D. Those who graduate from high school or those who leave high school near to graduation to enter employment or the armed services. An increasing number of these students want to return for full-time preparation to become technicians but do not have requisite preparation or need to refresh their scholastic skills and knowledge.

Detailed consideration of each of these groups follows.

GROUP A. STUDENTS WHO DID NOT STUDY THE NECESSARY COURSES

Students in this group generally have demonstrated their capabilities and have mastered enough of the basic language, numerical, and other skills to rate average or above on scholastic tests. However, they usually lack some of the mathematics and/or science required to enter technical programs. Often the reasons they have not studied the requisite courses are very good ones. Some examples are:

****Students from a high school which did not offer two years of mathematics, and perhaps did not offer chemistry or physics, at a time when the student could study the subject. Such students may have excelled in vocational agriculture or other subjects but lack the required courses to enter technical education programs.

****Students who planned to enter a baccalaureate degree program and therefore studied foreign language, social sciences, and other subjects but did not study enough mathematics and science to prepare themselves to start a technical program.

****Students with obviously high ability who became deeply involved in sports or other student activities but had no serious vocational objective and took general courses. High school counselors and teachers often recognize the capability of these students even though their academic record is only average. The difficulty usually lies in motivating the students. If such students had been caused to think ahead and select the necessary subjects, then they could have been prepared to enter a technical program when they finished high school.

****Students who found it impossible to schedule some of the required courses in mathematics or science because they changed schools several times or because there were limited offerings in some of the schools they attended.

****Vocational agriculture students who desired to become technicians in the agricultural or related fields and have an excellent high school preparation, including such applied biological sciences as animal husbandry, agronomy, and soil science, but who lack the chemistry required to enter the program of their choice. Similarly, students who want to specialize in the health occupations may have studied a biological and/or a general science, and perhaps a course in health in high school, but did not study the required chemistry or mathematics.

A pretechnical post high school program can provide the opportunity for students such as these to enter a technical program and thus more fully develop their capabilities.

GROUP B. STUDENTS WITH SPECIAL SCIENCE RELATED INTERESTS BUT UNDERDEVELOPED MASTERY OF ORGANIZED STUDIES

Perhaps students in this group are best typified by the high school ham radio enthusiast who spent a large part of his out-of-school hours constructing and operating a radio set at the expense of normal homework. English, mathematics, or formal science courses appealed to him only as they applied to his special radio problems. Students with consuming interests related to health occupations or to agricultural activities may also be found.

Many of these students have underdeveloped skills in language, arithmetic, and organized science. In high school they seemed less able than others in their classes because they did not acquire skills which enabled them to pass academic tests. They are students with special needs who represent a very important potential asset in specialized manpower.

Students with special interests in a science hobby are particularly promising as potential technicians because of their high motivation, consuming interests, and systematic approach to their particular hobby. Many concentrate on reading, mathematics, and science courses when they find these are directly related to their hobby, and they demonstrate a remarkable increase in so called "academic" ability by quickly and comprehensively mastering such courses.

Often technical programs are the only ones that interest such students or are the only ones they can enter. Many become excellent technicians and quickly demonstrate the ability and desire to undertake baccalaureate studies in the field of science. They, as a group, constitute an important source of highly skilled technicians. Pretechnical programs give them the opportunity to prepare themselves and realize their full potential.

GROUP C. STUDENTS WHOSE HIGH SCHOOL SCHOLARSHIP SUFFERED BECAUSE OF PART-TIME OR FULL-TIME EMPLOYMENT WHILE IN HIGH SCHOOL

Many high school students engage in part-time or full-time employment in addition to their school classes and activities. There are various reasons for such outside employment:

****The student's work is required on the farm or in the family business.

****The money earned may be needed to support the student or to augment the family income.

****The student may want the money he earns to support hobbies, a post high school education, or for some other compelling reason.

****The student may be naturally resourceful and energetic, and his interests lead him into employment in addition to his high school program.

The extra burden of part-time (or full-time) employment on someone who is competing in high school activities is often so great that his real scholastic capabilities cannot be demonstrated. He may be physically tired and unable to concentrate his full energies either in class or in outside study.

Such a student may appear unqualified to enter a technical program, but he could be a most promising candidate because of his interests, his habits and ability to work, his maturity, and his ambition. A pretechnical program to strengthen his scholastic background and to provide the courses he needs often is a great service to the student and the technical field.

GROUP D. STUDENTS WHO LEFT HIGH SCHOOL BEFORE GRADUATION

Students in this group may not have studied the necessary courses; may not have been strongly motivated toward school; or may have decided to leave high school and find employment or enter the armed services. They are usually from 2 to 5 years older than the average student technician.

Employment or military experience usually develops more mature work habits, better social judgment, added general information and sophistication, and greater stability. All of these assist such students when they return to school with a positive motivation. However, these students often lack some of the prerequisites of the technical program. In spite of their greater stability and strong motivation, they cannot successfully enter a good technical program until they have mastered the subjects needed to meet the entrance requirements.

These students may not have demonstrated outstanding scholastic ability in high school, but when they return to school with maturity and motivation, they prove to be excellent students. Pretechnical programs can encourage this group. They are another important source of technicians.

The needs of students in the foregoing groups —and many others who need to strengthen some of their skills in mathematics, science, reading, speaking, writing, or basic study habits—may be well served by pretechnical programs. There are many such deserving and promising persons. More pretechnical post high school programs must be provided to give them opportunity to develop their full potential and to meet the Nation's need for more technicians.

PROGRAM PLANS

The example of a program presented here shows the course schedule for pretechnical students who require courses in all requisite subjects to enter *either* a physical science and related engineering technology (based on applied physics) *or* a biological science based technology in agriculture or a health occupation. Pretechnical students would *not* be expected to study both preparatory physics and preparatory chemistry. The scope of the courses in a pretechnical program is to provide students opportunity to master the subject matter and related laboratory or other skills of each, equivalent to *above average* high school completion.

	Hours per week			
Subject	*Class*	*Laboratory*	*Outside study*	*Total*
FIRST SEMESTER				
Introduction to Technical Specialty (technology of student's choice)	2	3	4	9
Study Skills	2	2	4	8
Preparatory Communication Skills I	3	0	6	9
Preparatory Physics I *OR* Preparatory Chemistry I	4	4	8	16
Preparatory Mathematics I	4	0	8	12
Total	15	9	30	54
SECOND SEMESTER				
Preparatory Communication Skills II	3	0	6	9
Preparatory Mathematics II	4	0	8	12
Preparatory Physics II *OR* Preparatory Chemistry II	4	4	8	16
Preparatory Biological Science* (*optional for biological science technologies*)	3	4	6	13
Total	14	8	28	50

***If Biology is not taught, a Technical Specialty course completes the schedule up to 52 to 55 hours.**

If pretechnical students lack only mathematics and science (physics or chemistry) they would study:

First Semester

- Preparatory Mathematics I
- Preparatory Physics I *OR* Preparatory Chemistry I
- Introductory Technical Specialty courses with laboratory practice in the technology of his choice
- Other courses in technology *not* deeply dependent on mathematics or science (physics or chemistry)

Second Semester

- Preparatory Mathematics II
- Preparatory Physics II *OR* Preparatory Chemistry II
- Preparatory Biological Science (if in agriculture or a health occupation field, optional)
- Other courses in their technology not deeply dependent on science (physics or chemistry)

If pretechnical students lack only physics or chemistry, they might study:

FIGURE 5. Both underprepared and fully qualified student technicians can enter technical courses which are not strongly dependent on mathematics or basic science and have an equally good probability of successfully mastering the courses.

First Semester

- Intensive, accelerated Preparatory Physics, *OR* Preparatory Chemistry
- Introductory Technical Specialty courses with laboratory practice in their selected technology
- Biology (if agricultural or health related technology, optional)
- Other courses in their technology not deeply dependent on science (physics or chemistry)

Second Semester

- Full schedule of courses in their technology

While two semesters composed largely of pretechnical courses usually are required to improve the scholastic capabilities of the majority of the students, an intensive *one-semester* program may be sufficient for some. Scheduling such a program is justified if there are enough students whose knowledge and skills in communications, physics or chemistry, and mathematics can be raised to the required level in the shorter period.

An example of an accelerated, one semester pretechnical program follows:

Subject	*Hours per week*			
	Class	*Laboratory*	*Outside study*	*Total*
Introduction to Technical Specialty (technology of student's choice)	2	3	4	9
Preparatory Communication Skills	5	0	10	15
Preparatory Physics *OR* Preparatory Chemistry	4	6	8	18
Preparatory Mathematics	4	0	8	12
Total	15	9	30	54

The content for each of these preparatory courses is selected and designed to provide what each student needs to meet the required level of competence to enter the normal first semester courses in each subject in the technical curriculum.

In addition to the recommended two-semester course of study, *a one-semester pretechnical program* for students who could benefit from it may offer a special advantage to the school. It permits greater utilization of facilities and faculty especially if the one-semester program is given in the spring (or second) semester. The majority of students who leave a pretechnical or a regular technician program usually do so during or at the end of the first semester, and a one-semester pretechnical program in the second semester brings new students to the institution in place of those who recently left. A second semester program has the additional advantage of allowing pretechnical students from the spring program to enter the normal first semester courses of their chosen technical curriculums in the fall.

A summer pretechnical session which is patterned after the one-semester program may be feasible for some schools that can select exceptional pretechnical students. It has been observed, however, that *most students who need pretechnical preparatory study cannot do in a summer what usually requires two semesters* or at least one semester. Students who have *not* previously studied physics or chemistry *usually* cannot obtain sufficient comprehension or mastery of the subject in a summer session to undertake the first-year courses in a technical curriculum; only an exceptional few can prepare themselves in a single semester. A one-semester pretechnical program, and in rare instances a summer remedial program (if enough qualified students are available to justify it) usually should not be started until *after a two-semester program has become fully operative.*

Within the framework of available courses for pretechnical students, the pretechnical program should be designed to meet the academic needs of the student. Each student's program should be based on what he has already mastered. It should be designed to build up his deficiencies, in the judgment of the counselor and the student's faculty advisor, and challenge the student *but not overextend him.*

Pretechnical courses differ from first-year courses in a technician program; the subject-matter is taught at a different depth and is covered at a different rate. The basic philosophy of the pretechnical program is to provide individual instruction for each student as much as possible in a classroom situation. Students will find a greater degree of satisfaction and accomplishment and the instructor can be more effective if the students are at a similar level when the classes begin.

Classes for pretechnical students in study skills, mathematics, and basic science should be taught separately from courses in the same subject for the first-year student technicians. The most successful techniques of teaching mathematics, basic science, and reading to pretechnical students differ from those used in the first year of a technical program because the subject matter and class objectives are different. However, pretechnical students *should study their elementary technical courses in the same classes* as regular first-year technical students.

It is essential that pretechnical students be considered on the same social basis as all others. School regulations, social codes, dress, attendance, and all other aspects of a student's behavior should be the same as that of the entire student body. As their study schedules and capabilities permit, they should enjoy all the privileges and responsibilities granted to other students in the school.

Objectives of the Programs

Pretechnical post high school programs have at least three objectives: (1) development of skills; (2) development of attitudes; and (3) development and preparation in subject matter to the required level for entering a technical curriculum.

While these three objectives are interrelated, each should be considered separately. Students whose scholastic preparation does not meet prerequisite levels for technical curriculums may lack well-developed reading and study skills; may have attitudes inconsistent with maximum performance; or may never have formally studied some of the required courses.

Clearly, the pretechnical program should be designed to enable the student to acquire the attitudes, skills, and academic preparation he needs to undertake a technical curriculum with a good probability of successfully completing it. *The subject matter taught must be within his learning capability within the time allotted to the pretechnical program.* A student whose deficiencies are so great that he probably cannot succeed in a pretechnical program should be guided toward other objectives.

Underdeveloped study or reading skills adversely affect the student throughout his academic career regardless of academic level or objective. Ability to study is often almost synonymous with ability to read. Study skills and reading skills are like quality tools to the craftsman and are an indispensable means to achieve success in scholastic effort.

Attitudes which a student must possess to succeed as a technician are: a special interest in his field, ambition, integrity, intellectual honesty, confidence, resourcefulness, patience, inquisitiveness, and willingness to work and study systematically and continually in order to meet his occupational objective. These attitudes can be developed and strengthened in a pretechnical program. The course in study skills—plus individual counseling—can often help a student develop confidence and a strong positive attitude toward his program. Nurturing proper attitudes consistent with standards of success can aid many pretechnical students in developing a high potential for study and success.

A third objective of a pretechnical program is to provide an *opportunity* for students *to study subjects* required to support their technology programs which they either have not mastered or have never studied.

When pretechnical students enter an institution to become technicians, they must adjust to a different environment. They should develop a "college student's" attitude toward the faculty, freedom in class schedules, responsibility for scheduling and using their time, and independent use of facilities such as the special learning laboratories and libraries. The pretechnical program of courses and special guidance introduces the students to the college environment. Students in pretechnical courses must have a full schedule of class, laboratory, and outside study; otherwise they often develop study and work habits which may lead to failure in a technical curriculum demanding rigorous self-application.

Outside study is a significant part of the student's total program. Two hours of outside study time has been sugggested for each hour of scheduled class time. A typical weekly work schedule for a student in the first semester of a pretechnical program would be: Class attendance, 15 hours; laboratory, 9 hours; outside, 30 hours—a total of 54 hours per week. This is a full schedule, but not excessive for such a program. The second semester weekly schedule should be from 52 to 55 hours. These schedules are typical of the weekly schedules in technical curriculums, and in view of the age, aspirations, and stated objectives of pretechnical students, it is both reasonable and necessary that they adjust to the rigorous schedule of a technical curriculum when they are enrolled in a pretechnical program.

Advantages of Full-Time Study

Pretechnical programs of less than a full schedule of study have usually proved to be of less than maximum effectiveness. Students in part-time programs tend to develop poor study habits, may attempt full- or part-time employment, or may become involved in other activities that interfere with their program. As a result, they may lose interest and abandon their studies. In such cases, the program has failed to serve either the student or the institution.

Some of the most important advantages of a full-time pretechnical program are:

1. The student *totally committed* to the program is found to be more serious and conscientious.
2. The student develops a more normal identification with other students in the institution.
3. The student has a greater opportunity to explore career choices, greater access to library materials, and more time to discuss career choices with trained counselors.
4. A full-time program shortens the time required for a student to raise his qualifications, and as a result shortens his whole post secondary educational program. This

enables him to become a skilled technician, obtain employment, and thus attain his scholastic objective in the shortest time possible within his capabilities.

5. A full-time student can more easily qualify for certain State and Federal scholastic aid funds.
6. A full-time program permits the college to fully develop the program's effectiveness. Faculty and counselors can be employed and assigned to teaching in the program on a full-time basis.

Experience shows that pretechnical students should be encouraged to do as much of their outside study as possible on campus — in the classrooms, laboratories, library, and any other place that can provide a favorable environment for study. *This is especially important for students who commute from home to school.* Many pretechnical students do not have an optimum environment for concentrated study at home. They often find that the "study-oriented" environment at school—free from distractions of home, family, friends, hobbies, and other recreational attractions—makes it possible for them to develop good study habits, master the subject matter required, and achieve the scholastic success on which their future depends.

SPECIAL ADMINISTRATIVE CONSIDERATIONS

Special consideration must be given to several important factors in initiating and developing pretechnical post high school programs. These include general administrative policy; possible availability of Federal support; use of an advisory committee; selection and development of the required special faculty; provisions for counseling and advisory services to students and parents; required physical facilities such as classrooms, special learning laboratories, and a library; and the cost of the program.

Pretechnical post high school programs provide several advantages to the institution which offers them, including:

1. A source of a larger number of qualified students. This permits graduation of a larger number of highly skilled technicians to meet the employment needs of the community, region, or Nation.

2. A reduction in the loss of students because of scholastic failure during the first semester or first year. This is very important. In many technical programs, the first year loss of students is 40 percent and in some as high as 60 percent. To lose so much of a class reduces effectiveness in the utilization of facilities, requires instructors to teach smaller classes than are economically ideal, and usually lowers the morale of the student body.

3. Assurance of uniformly *higher quality graduate technicians* from their technical curriculums. Strengthening the preparation of promising students to meet the scholastic level required for successful mastery of the whole technical curriculum provides uniformly well-prepared classes of students in each technology. Such students are capable of acquiring the depth of knowledge and developing the specialized skills required of highly qualified technical school graduates.

4. Aid in student recruitment for *certain specialized fields of technology* in which there is a shortage of qualified students. Pretechnical programs provide opportunity for students to qualify for entry into technical programs which might not otherwise have sufficient enrollment to be effective or even to be offered by the institution.

5. Favorable support for the institution from parents, high school administrators and counselors, employers, and civic leaders because youths are given an opportunity which they probably could (or would) not overcome if the pretechnical program were not available.

Pretechnical programs should be high quality and continuing programs. The specialized teaching staff and the experienced counselors required to provide a successful pretechnical program cannot be obtained on short notice and will not reach maximum effectiveness during the first year or two of the program. Pretechnical programs should be undertaken by institutions to meet a clear and continuing need, and when started, they must be supported as fully as other programs in the institution if they are to serve their purpose.

When a technical program is initiated, it will be most effective if it is sympathetically accepted and supported by the entire staff of the institution. Usually the number of pretechnical students in the institution should be a significant percentage of the school population if it is to be successful and is to serve the needs of the community effectively. It may well account for more than half of the beginning students each year in some institutions.

Acceptance and support of the program by all the staff — especially teaching, counseling, and advisory staff — is necessary to insure that pretechnical students are recognized on the same social and scholastic basis as all other students in the institution. Policies and systems of grading, complete student records, charges for tuition, housing, and student laboratory and activities fees should apply uniformly to pretechnical and other students alike. As previously indicated, pretechnical students—like other students—de-serve the best service and must be completely accepted as participating members of the school and its activities.

Both students and their parents should completely understand the objectives of a pretechnical program. The unusual characteristics of the program should be fully explained to both. This is especially important when requisite levels and the method and plan for improving the student's scholastic preparations are discussed. The orientation of both the student and his parents helps them understand and cooperate in supporting the student's program.

The institution must recognize that while most students who successfully complete the pretechnical courses will want to continue in the technical curriculum of their choice, some for various reasons may choose to continue their education in some other institution. Counselors, advisors, and registrars in the institutions should assist students who want to go elsewhere as a part of the institutions' services to the student. It is not uncommon for pretechnical students to progress so rapidly and to find scholastic interests so exciting that they want to undertake baccalaureate programs in science, engineering, agricultural, premedical, and other fields. They should be encouraged to explore all factors in their selection, guided toward a mature choice, and assisted in its attainment.

The fact that some students will elect to go elsewhere should be considered in planning the size of the pretechnical program. To the degree that recruitment of student technicians is an objective of the program, the number of pretechnical students recruited and accepted should be increased by some factor to allow for those who will leave the program.

Federal Support

The Vocational Education Act of 1963 makes clear in its statement of purpose that programs for students with special educational needs can be supported as they prepare for gainful employment:

> **Section 1. It is the purpose of this part to authorize Federal grants to States to assist them to maintain, extend, and improve existing programs of vocational education, to develop new programs of vocational education, and to provide part-time employment for youths who need the earnings from such employment to continue their vocational training on a full-time basis, so that persons of all ages in all communities of the State—those in high school, those who have completed or discontinued their formal education and are preparing to enter the labor market, those who have already entered the labor market but need to upgrade their skills or learn new ones, and those with special educational handicaps—will have ready access to vocational training or retraining which is of high quality, which is realistic in the light of actual or anticipated opportunities for gainful employment, and which is suited to their needs, interests, and ability to benefit from such training.**

Students who qualify for pretechnical programs clearly are persons who must overcome educational handicaps in order to profit from instruction in an organized educational program of their choice which has the objective of gainful employment.

Pretechnical programs can be supported under The Vocational Education Act of 1963 in any State or Territory if the State plan makes provisions for educational programs for persons with special needs. For the pretechnical program to qualify for support under the Act, the institution which teaches technicians must make provisions for the pretechnical program to be included in the overall plan for educating technicians. Pretechnical students must make application to the institutions with the declared objective of entering a technical program. This legally establishes their identity as students under the Act. After being accepted, they can complete the necessary pretechnical and regular technical courses to permit them to graduate from the institution as technicians in their chosen field.

Advisory Committees and Services

Experience has shown that almost all successful pretechnical post high school programs are assisted by the services of advisory committees and special consultants. Most institutions have an advisory committee or committees to assist the administration in planning and implementing overall programs to meet the objectives of the institution and the needs of those it serves. In addition, each specific technology or other specialized program, including the pretechnical program, has a special advisory committee made up of representatives of employers, local high schools, civic leaders, public employment services, scientific or technical societies and associations, and the administrative staff of the school.

The advisory committee usually is appointed by the chief administrator or the dean of the institution when it becomes evident a pretechnical post high school program should be considered by the institution. The advisory committee then assists in making the necessary survey of the need for the pretechnical program, whom and how many it would assist, special requirements of the available student population, counselors and faculty, learning laboratory and library facilities, equipment, how to inform the public about the program, and its cost and financing.

The studies of the advisory committee may show that a proposed program should not be undertaken. However, when studies do show that a pretechnical program is needed and can be given complete administrative support in the form of permanent staff, facilities, and equipment, the advisory committee can assist in its publicity and promotion with the public.

Committee members usually are appointed for a year so the duties will not become a burden to any individual member and to give other qualified and interested people the opportunity to serve. The average committee usually consists of about twelve members, but the number may vary from six to twenty. Those selected to serve are usually busy people, and meetings should be called only when there are problems to be solved or tasks that committee action can best accomplish. The head of the institution or department head of the related program usually acts as chairman. Such committees serve without pay as interested citizens. They enjoy no legal status, but provide invaluable assistance, whether serving formally or informally. The continuous support of an advisory committee has been found to be a constant source of strength for the program.

Experience shows that services of a special advisory committee can be particularly effective in studying the needs for pretechnical programs, determining their potential service to students, and recruiting the number of *qualified* students required to support technical programs in the institution. If a program is initiated, the committee can provide invaluable assistance by communicating information about it to parents and the general public and by actively supporting the program in discussions with high school administrators and counselors, and parents.

As stated in the foreword, this publication is intended as a guide for program planning and development. It may have to be adapted to suit individual school situations in different localities. The assistance of an advisory committee and special consultants, using a guide such as this as a starting point and modifying it to meet local needs, is an effective means of initiating needed programs and developing them quickly to a high level of excellence.

Student Selection

Since pretechnical post high school programs provide a special service to students, the selection of those students is of primary importance. Pretechnical students may devote most of the school year, or of one semester, to preparing themselves to enter an educational program which they *are not qualified to enter without the pretechnical study.* To permit them to enter a technical program without the necessary preparation invites failure of the student or of the program or both; causes disillusionment of students and their families; and is a disappointment to the school. It is important to emphasize to potential students that the time and energy devoted to a pretechnical program prepares them for opportunities which are not available to them without the program and they should not attempt to enter a technical program of advanced study at the college level without pretechnical preparation.

The decision to enter the program must reflect the student's desire to undertake it with a full knowledge of its nature and its potential contributions to his occupational aspirations. It is important that pretechnical students:

1. *Want* to enter the program.
2. *Accept* the fact that it provides an opportunity to prepare them for the occupation of their choice.
3. *Realize* that pretechnical preparation is necessary before they enter a technical education program if they are to succeed in the

rigorous preparation required of a technician.

4. *Are willing* to devote the time, energy, and money required to undertake the program on a serious, first priority, and full-time basis.
5. *Reasonably expect* to successfully bring their scholastic preparation to the required level to undertake a technical curriculum *within the duration of the pretechnical program.*

Selection of students for a pretechnical program must be based on evaluation of all the pertinent information available and the judgment of the admissions personnel of the school. Some students who apply for admission to technician programs may be unaware that they could profit from the pretechnical program or that they require preparatory courses to qualify for entry. They should be informed about the pretechnical program and encouraged to accept the opportunity it provides to strengthen their scholastic preparation. Active recruitment will encourage students to apply for admission to the pretechnical program.

Applicants for pretechnical post high school programs should be evaluated as carefully as other applicants for technical programs. Whenever possible, the evaluation should be based on comparable data. All available information including the student's high school records, recommendations from his high school, and any available test data should be considered. If a testing program has been developed for admission to the technical programs, the same tests should be required of the pretechnical program applicants. A few examples of the many available tests which may be used are:

College Entrance Examination Board	(CEEB)[1]
American College Testing Program	(ACT)[2]
College Qualifying Test	(CQT)[3]
American Council on Education	(ACE)[4]
General Abilities Testing Battery	(GATB)[5]

It is assumed that each institution will select tests, or batteries of tests which best meet its own admission standards for all applicants. It would be impossible to list all available tests; the foregoing are but a few examples.

A personal interview of all applicants to pretechnical programs is recommended. Evidence of interest and readiness for a pretechnical or technical program may best be determined in an interview. Applicants who have been employed or served in the armed services may demonstrate their maturity and motivation more clearly in an interview than on a written application. Military training and/or work experience contributing to interest and readiness for technical education may also be discussed and evaluated.

The success or failure of the pretechnical program will depend in large measure on the experience and judgment of the interviewer. Evaluation of each applicant necessarily involves a certain degree of subjective judgment. Because of this, it is suggested that each institution which starts a pretechnical program should keep comprehensive records for each student. In doing so, the institution may find the *relative value of criteria* used in the admissions decisions becoming apparent over a period of years. An analysis of student performance compared to the records of admission data may suggest modification of the weight of certain admissions criteria based on the accumulated experience.

Each applicant's interest in and aptitude for the technical program he is applying to enter should be carefully evaluated. Pretechnical programs may attract applicants whose interests and abilities might be better utilized and more rewarded in an occupation other than that of a technician. They should be guided toward areas that best serve their talents and offer probable success.

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[1] College Entrance Examination Board, 475 Riverside Drive, New York, N. Y. 10027

[2] American College Testing Program, 5197 Sheridan Road, McHenry, Ill. 60050

[3] College Qualifying Test, The Psychological Corporation, 304 East 45th Street, New York, N.Y. 10017

[4] American Council on Education, 1785 Massachusetts Avenue, N.W., Washington, D.C. 20206

[5] U.S. Employment Service, U.S. Department of Labor, Bureau of Employment Security, 1730 M Street, N.W., Washington, D.C. 20002

The ability of the applicant to meet the physical requirements imposed by the college curriculum and by the field of technical employment he plans to enter should also be carefully considered. If, for example, an applicant were color blind, he should be advised of the resulting limitations if his technician duties required him to be able to make clear differentiations in color. The record of a recent comprehensive physical examination should be a part of the information available about an applicant and should be considered by the admissions officer.

The acceptance or rejection of a student seeking admission to a pretechnical program must depend on whether, in the judgment of the school and based on all available information, he has at least the minimum potential for success in the preparatory program *and in the technical curriculum* of his choice. The applicant's attitude, past educational performance, tests, recommendations, employment experience, and hobbies must be evaluated; and, as stated before, he must *want* to be accepted.

Faculty

The effectiveness of a pretechnical program depends largely upon the competence and the enthusiasm of the teaching staff. The specialized nature of the program requires that the teachers of each subject have special teaching competencies based on professional proficiency in their subject matter and a special interest in assisting students beyond the traditional teacher-student relationship. They must be *master teachers.* It is essential that all members of the faculty *understand and accept* the educational philosophy, goals, and unusual requirements that characterize a pretechnical program.

To be most effective, members of the faculty responsible for this program must have interests and capabilities which transcend their area of specialization. All of the faculty members should be reasonably well acquainted with the requirements for study in the various technical curriculums so that they may use examples or subject matter as supporting material which will appeal to the students in their respective courses.

Teachers should have a strong and obvious desire to teach and to help the students develop. Sympathy and empathy toward the pretechnical student are essential qualities. Their effectiveness with many of their students will depend more on their sensitivity and perceptiveness of the student's individual learning problems and their ability to communicate with him than on knowledge of technical subject matter. Patience and understanding are especially important traits for the teachers to possess.

Teachers ideally should have had a varied experience in different levels of education. Teachers who have had considerable experience with students of high school age tend to have a greater understanding of pretechnical students' problems and attitudes than those who have had only college teaching experience.

Many excellent technical teachers are not psychologically prepared for pretechnical instruction because of lack of sympathy with pretechnical students and their objectives. They may never have found scholastic effort to be slow and difficult, and therefore do not understand students who must strive to develop understanding of relatively elementary subject matter in basic scholastic preparation. Impatience toward students who have underdeveloped verbal or other abilities or who find some learning difficult is detrimental, and teachers with such feelings cannot be effective in a pretechnical program. Students can sense the teacher's impatience and may consider it an implied criticism of their capabilities. Teachers who volunteer to teach in the pretechnical program have usually been found to be most effective. Teachers should feel that it is a welcome professional challenge to teach pretechnical students and must exhibit a genuinely enthusiastic, friendly, and helpful attitude toward their students if the program is to be most effective.

Employment experience in industry or business is excellent preparation for all teachers, and especially for teachers in pretechnical programs. Often the real understanding of situations in work experience can bring student and teacher closer together and strengthen the teacher's ability to communicate with and motivate students.

When a pretechnical program is initiated, additional instructional staff members will be required. Some may be obtained from the staff of the regular program at the school. New ones must be recruited, perhaps from high schools or from non-teaching sources in business or technical employment.

Experience has shown that technicians who graduated from 2-year technician programs, acquired employment experience, and continued a professional education which prepared them to teach often become excellent teachers in a pretechnical program. Persons with this kind of background are more likely than others to understand the objectives and unusual instructional requirements of both pretechnical and technical programs. They often bring to the program a special enthusiasm and appreciation for the values of technical education and an understanding of student learning processes that are essential for its success.

Close coordination of all members of the teaching staff in a pretechnical program is important in order to integrate the subject matter of various courses, both in pretechnical courses and in the beginning courses of a technical specialty.

A weekly departmental staff meeting to encourage the development of "team teaching" is recommended. At these meetings each instructor should check with instructors of concurrent courses to insure that close coordination is being maintained. This is especially important when new techniques are involved. If less than optimum coordination is evident, important factors can be analyzed by those involved, and a solution to the problem found quickly. It is expected that there will be duplication of subject matter in the *study skills* courses and the *communications* courses, but such duplication should cause each teacher and each course to strengthen and reinforce the other. This requires close cooperation between the teachers of all courses to avoid presenting the same material in the same way in a different course.

In addition to keeping concurrent courses well coordinated, staff meetings should also provide time for free exchange of ideas on teaching techniques discovered to be useful, and on recently developed teaching methods or devices which seem to be particularly successful. Any project which appears especially interesting and beneficial in teaching pretechnical students should be analyzed to see if the same principles of presentation can be employed in developing other projects. Special attention should be given to articles in current professional journals that present new information about teaching and learning.

Teachers of pretechnical programs should make extensive use of teaching aids. Ideas presented visually are usually better and more easily understood than those presented verbally. One of the characteristics of many pretechnical students is underdeveloped verbal comprehension. Some not only are slow readers but also need assistance and training to improve their speaking and listening capabilities. Overhead projectors utilizing ingeniously prepared transparencies are valuable devices in many class presentations. Much has been learned about the value of programed learning, and such materials should be used whenever they will help a student to solve problems in any of his courses. (See Appendix C for sources of visual aids and programed learning materials.)

The highly personalized techniques of teaching required in pretechnical programs make it necessary for class sections to be small, usually ranging from 10 to 30 students. Pretechnical students cannot receive the necessary individual attention in larger classes. Students in a preparatory program exhibit a wide variation in rate of subject mastery and scholastic skills when they enter the program. Individual help which many students need with specific problems is required from the teacher and can be provided best in small classes.

The teacher must frequently evaluate each student's progress. The teacher, as well as the student, will be motivated to do better work and to try harder if each can sense a degree of progress and success. Facts revealed by frequent evaluations are essential to the teacher in assisting a student who is not progressing at the expected rate. Frequent quizzes, prompt return of homework assignments, and personal conferences with each student on his progress are mandatory to the success of the program.

When determining teaching loads for instructors of technical specialty courses, officials should consider the number of student contact hours required. Fully effective specialty instructors require more time to develop teaching materials and have individual conferences with students than teachers of general courses. A contact-hour workload of not more than 20 class hours per week usually should constitute a full schedule for pretechnical program teachers. The rest of their time should be spent in assisting students (often in individual conferences) and developing effective visual aids or other teaching materials for their courses.

To keep a staff effective, officials should encourage faculty members to actively participate in professional and technical societies. Membership in such organizations will acquaint them with the latest literature in the field and help them to keep in closer touch with the most recent practices in teaching, guidance, and counseling. School administrators are increasingly encouraging self-development by authorizing released time and financial assistance for instructors to attend technical meetings and training institutes. Periodic or sabbatical leaves give staff members opportunities to increase and up-date their professional training and to pursue advanced studies. Teachers for pretechnical post high school programs must be *master teachers* and must constantly be encouraged and given the opportunity to improve their practice and understanding of the art of teaching.

Student Counseling, Guidance, and Advisory Services

Many students in pretechnical programs need and can profit from more counseling and personal guidance than schools normally provide for technical students. Some pretechnical students who have been out of school — in the armed services or employed — may find adjustment to a rigorous scholastic program very difficult. Others will need counseling to help them with personal problems and to help them develop confidence in their own scholastic habits and abilities. Many may need counseling on financial and even family adjustments as they develop their attitudes and study habits to meet the demands of a college environment.

Counseling for personal problems usually is most effective with special staff counselors whose duties and relationships to students can be separated from teaching and classroom responsibilities. Such a counselor-student relationship permits a more intimate and objective exchange of confidences and advice between the student and counselor than when the counselor has a teacher-student relationship.

Full-time counselors must have special personal characteristics and must acquire the ability to communicate with students in groups or individually. They must win students' confidence and try to arrange opportunities to become personally acquainted with those who can profit most from their guidance and assistance. Full-time counselors seldom can be effective if they approach their work on an "office hours" basis. Students with the greatest need for counseling and assistance often are least likely to seek out a counselor or bring his personal concerns or problems to the counselor in his office.

Counselors must have easy access to all official school records of each student they are responsible for and should maintain a brief but complete record of their personal advice and services to each student.

Full-time counselors in institutions which house their students on the campus have more opportunities to meet and get acquainted with students in dormitories, at meal time, and in organized campus living and social activities than counselors in schools with students commuting. The counselors in the latter institutions must be especially imaginative and resourceful to find ways to open channels for personal contact with students.

All students should be assigned to a *faculty advisor* when they enter the school. The faculty advisor's function is traditional — assisting and advising students on selecting and registering in courses, scheduling classes, and related administrative matters. The faculty advisor for pretechnical students should usually be the department head or an instructor in the special technology program each student wants to study. All faculty advisors for pretechnical students must be sincerely sympathetic with the pretechnical program and discharge their duties in a manner which encourages the students to want to succeed in their program, and become a technician in their chosen technical field.

All teachers and advisors of pretechnical students must be alert to indications of any problems with which the counselors might assist the students. Close liaison between teachers, advisors, and counselors—usually on an informal basis—is necessary to the success of the program. Counselors and advisors should participate regularly in the weekly pretechnical program staff meetings.

Pretechnical students' problems of learning and adjusting to the new challenge of special occupational education are generally the same but of a different degree from those experienced by fully qualified first-year technical students. The counselor's primary goal is to try to learn *what the student's problems are* and how the student and staff can solve them. If the student's only problem seems to be underdeveloped scholastic capabilities, the teachers and counselors are challenged to strengthen the student's confidence and motivation, and especially to help him master the preparation courses so that he may qualify to enter the technical curriculum of his choice.

It should be assumed that some students need direction and must be encouraged more than others or they may, at times, lack motivation to continue their efforts. Some pretechnical students will find the first semester very difficult because they have never experienced any satisfaction and really successful scholastic accomplishment in previous school experiences. It requires a high degree of skill and sophistication for a teacher, faculty advisor, or counselor to discover the real causes or reasons for some pretechnical students' concerns and to help them to overcome their problems.

The challenge to the counselors of pretechnical students is first, to discover and overcome any evident psychological obstacles to the student's progress because of his attitudes or study habits and then, to establish a relationship of mutual understanding that keeps channels of communication open and permits effective counseling and encouragement for the student.

The responsibility of the counselor is to discern the student's problems and strengths, to accentuate these strong points and interests, and guide the student in feeling successful in his scholastic effort. Factors which hinder learning are often complex and difficult to discern, but the rewards to both student and counselor are most satisfying when these are identified and overcome.

An essential service of teachers, advisors, and counselors in the institution is to provide extended occupational guidance to some students. Through close acquaintance with individual students counselors may find evidence that some should be guided to a different occupational objective. For example, it may become evident that the "hot-rod" automobile-oriented student is more interested in becoming a highly qualified automobile mechanic than a mechanical technician. Guidance of this sort is a valuable service to the student. Leading able students with special interest to an objective occupation in which they can and will succeed and in which services are badly needed is a distinct and important service not only to the students but also to the community. Students who undertake a new occupational objective gain appreciably from post high school pretechnical programs. They improve their English, mathematics, or science, and they are assisted in identifying and concentrating on preparation for an occupation which suits their particular needs, interests, and capabilities (even though it may not be that of a technician).

Adequate provision for faculty advisors and counselors is an indispensable part of the organization of a pretechnical post high school program.

PHYSICAL FACILITIES AND THEIR COST

Laboratory and related classroom, office, and storage facilities required for teaching a pretechnical post high school program do not present special or unusual conditions peculiar to the pretechnical program. Any well-constructed building with suitable utilities may be used. However, if the program is to be a part of a new building, plans should include maximum use of movable partitions and portable equipment to attain greatest flexibility and utility of space. If a new library is contemplated there are attractive advantages to including the special basic study skills laboratory in the library, especially if audiovisual aids and individual programed learning materials are to be centered in the library.

The space and facilities required are basically those needed for each course studied by pretechnical students. Sufficient classroom space is required to accommodate the additional number of students brought to the institution for the pretechnical program, but the class or lecture rooms used for mathematics, communication skills, physics, chemistry, or biology and the technical specialties may be the same as for the regular technical curriculum. It is also assumed that the chemistry, biology, and physics laboratories available in the institution will suffice for the pretechnical program, provided the facilities are available the required number of hours per week to permit scheduling of the pretechnical laboratory sections. The special laboratory for teaching basic study skills is a unique facility required for pretechnical programs and will be described in detail later.

The size of classes for pretechnical programs, as previously indicated, should not exceed 30 students for lecture and recitation classes in communication skills, mathematics, science, or the technical specialties—if possible they should be limited to 25. Laboratory study groups in biology, physics, or chemistry should not exceed 25 and ideally should be smaller. To provide for the close supervision, individualized study and instruction, and daily evaluation of progress which a pretechnical program demands, *basic study skills class or laboratory sections should not exceed 16 students.*

Whenever possible pretechnical students should be given an opportunity to learn by doing. This applies to *active recitation* in class as well as performance of experiments in laboratories. It is through an *application* of new information that students in a pretechnical program become highly motivated and begin to realize inter-disciplinary relationships. It is through the application of principles that a technical student can develop a scientific attitude. The value of participation and *doing* cannot be overestimated or overemphasized in teaching pretechnical students, particularly when they are learning the basic language, numerical, and scientific skills they need as tools to attain scholastic accomplishments previously beyond their reach.

Equipment Selection and Acquisition—General Considerations

The cost of establishing and equipping the special basic study skills laboratory and teaching a pretechnical program will be found to vary somewhat depending upon the distance from major suppliers, the size of the department, the quality and the quantity of equipment or supplies purchased at a given time, and the method of purchasing. If the purchases can be combined and made through a central purchasing agency or under State contract, the total price of equipment and supplies may be significantly less than if the items are purchased separately. Small purchases of scientific and specialized education equipment or supplies usually are not subject to the same discounts as purchases of large quantities are.

When plans to establish, enlarge, or re-equip a pretechnical program reach the point where a detailed and precise estimate of costs is required, it is suggested that major suppliers be consulted so that cost estimates may be complete and sufficiently accurate for current budgetary purposes. Prior to a major purchase of equipment, a thorough investigation of the potential suppliers should be made by the department head or instructor. Major changes are constantly being made in the manufacture and supply of educational materials and equipment and these affect the final choice. The purchase of up-to-date equipment of good quality is an important factor in a successful pretechnical program. Experience has shown that the department head or instructor should make final decisions on the choice of laboratory equipment because he knows more about the technical details. The instructor can avoid costly mistakes which often result if nontechnical personnel attempt to equip a study skills and readying laboratory.

Research in basic study skills, the psychology of reading, and the teaching of reading has resulted in the development of a considerable variety of reading analysis and teaching equipment and apparatus. Some is very sophisticated; it may combine the projection of pictures from films or slides with sound or incorporate many refinements — regulation of operating speed, starting and stopping, reversing and rerunning, and other special aids or features designed to make teaching more effective.

There is an increasing number of manufacturers of instructional units. The effectiveness and excellence of their products place preassembled equipment systems in the laboratory which are designed specifically as teaching units, thus saving considerable time and effort for the instructor who would have to build or assemble such systems or use separate units which might have limited effectiveness. When equipping a learning laboratory, the planners of the teaching program and laboratory equipment should make *a thorough study of all the diagnostic and reading laboratory teaching systems available at that time.*

Experience shows that when purchasing packaged systems of instructional equipment the department head or instructor responsible for their use should be satisfied that they are completely operable and suitably serve the purposes for which they are intended. Preferably packaged systems should be demonstrated and operated by the instructor or department head. An essential assurance of satisfaction to both the buyer and the seller is a provision in the sales contract for a qualified representative of the selling agency to install complex or very expensive units or systems of laboratory equipment and for a test period of operation after installation.

The Library to Support the Program

Rapid changes in applied science and technology make it imperative that the students of any technology learn to use a library. Therefore, instruction for pretechnical students should be library-oriented so they will learn the value of being able to find new information and form the habit of using the library as a learning tool. This helps teach them to use the library throughout their total technician preparatory program and helps them develop the habit of studying in the library where materials are available and the environment is favorable to concentrated study. Pretechnical students should learn library skills as early as possible in their program.

Instructors of all pretechnical courses should keep the student constantly aware of how much the use of the library is a part of his study. Planned assignments requiring the student to use the library will teach him about the resources available and their relationship to the student's technologies.

Study space with suitable lighting and freedom from outside distractions and with ample reference librarian service should be provided in the library, and provisions for loaning reference materials should be systematic and efficient. The individual carrels, study rooms, and group and individual learning equipment in the library should be considered as auxiliary and supplementary to the special facilities for teaching basic study skills in a pretechnical program.

The library must contain especially selected literature and materials related to all subjects in pretechnical courses. Books, references, special programed instruction, and audiovisual materials for use in any pretechnical program offered by the school should be adequately represented in the library. Materials for these courses include: (1) language and communications teaching materials which emphasize grammar, speaking, spelling, elementary composition, reading, com-

FIGURE 6. A library with ample study space and materials selected to meet the needs of underprepared student technicians provides them with both a study area and experience in library use which is essential for all technicians.

prehension and vocabulary development; (2) materials for mathematics, starting with arithmetic and proceeding to the college level mathematics required for regular courses in any technology; (3) science materials, including physics, chemistry, and biology at the upper high school level as required for pretechnical courses; and, finally, (4) special materials for basic study skills. It is necessary that there be sufficient copies to permit students in the pretechnical courses ample access to such materials.

The teaching staff and the library staff should actively cooperate concerning what materials are to be acquired. The teaching staff should be responsible for the final selection of the materials which support pretechnical courses and they must take the initiative in recommending materials to keep the library content current, pertinent, and useful. The library staff should supply the teaching staff with a periodic list of recent materials, announcements, and acquisitions, complete with call numbers. Technical and trade journals either should be circulated to the teaching staff or placed in a staff reserve area for a short time before they are made available for general library use. Students in pretechnical courses usually exhibit special interest in trade and technical journals and manufacturer or suppliers literature related to their field. This interest should be supported and encouraged.

Visual aid materials may be centered in the library and are an important part of pretechnical course instruction. Visual aids should be reviewed and evaluated as they become available by both the librarian and a member of the teaching staff. This procedure tells the teaching staff about visual aids that are available and may suggest where they can most effectively be used in programs for pretechnical students. Visual aids should always be previewed and analyzed for timeliness and pertinency before being used in a teaching situation.

A well-equipped modern library should have some type of duplicating service available so that students and staff may easily obtain copies of library materials. Such a service allows both to build up-to-date files of current articles appropriate to the courses in a curriculum. This service should be available to all students, including those in a pretechnical program, at a minimum cost and should be free of personal cost to the teaching staff.

It is recommended that a minimum of $2,000 to $2,500 be budgeted for the initial purchase of library materials specifically selected for pretechnical student needs. An appropriate annual budg-

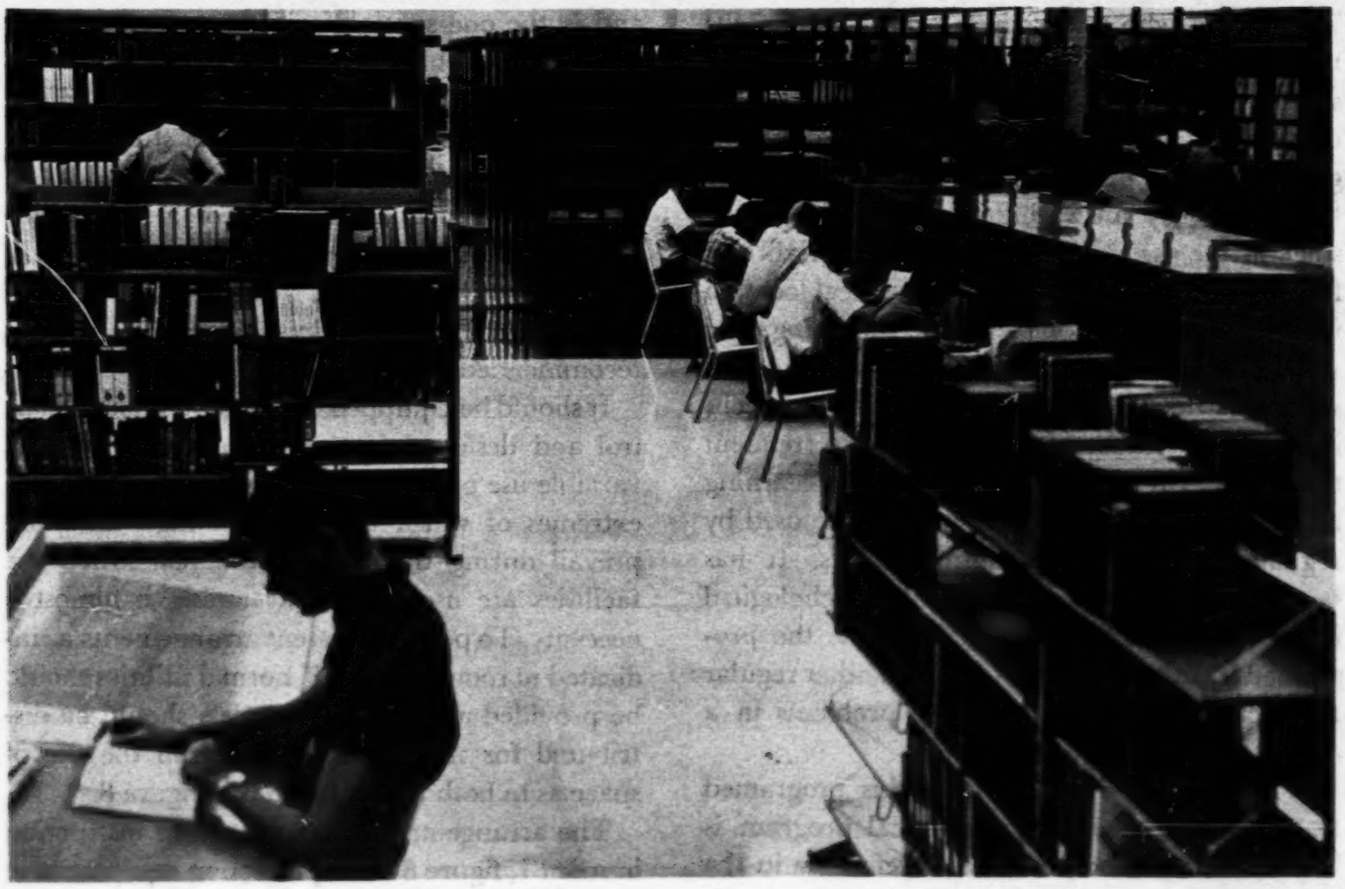

FIGURE 7. A study area, preferably a part of the library, equipped with programed learning materials is a recommended supportive facility in addition to the study skills (reading) laboratory for underprepared student technicians. Individual study carrels such as shown in the upper right help students to form better study habits.

et should then be allocated for keeping the materials up-to-date and replaced with new materials. If individual programed learning materials for pretechnical students are a part of the library budget, an additional $1,500 to $2,000 initial expenditure should be allowed, plus an appropriate increase in the annual budget for renewing the materials.

Programed Learning Outside Study Area

It is recommended that in addition to the special basic study skills laboratory a sizeable study area be provided, preferably in the library, where pretechnical students may have access to programed instructional materials in mathematics, science, communication skills, and subjects related to their technical specialty. This recommended study facility adds two important elements to the pretechnical program:

1. It provides a place which is equipped with the facilities and materials for study outside of class with a minimum amount of supervisory attention or assistance. Pretechnical students may go there for concentrated study on their particular subject problems.
2. It provides a necessary and special facility for students to do their studying on campus and away from other student activities. This is especially important and is almost required in schools where students commute and need on-campus, non-classroom study facilities.

This outside-study programed learning area should usually be established in the library because the library staff is trained in the systematic storing and loaning of materials, including programed learning materials. The library staff can also supply a reference librarian or a similarly trained person to assist students in their use of individual programed materials. It is generally recognized that programed materials are complete within themselves, but experience has shown that students progress much more effectively when they can turn to someone for help if they encounter problems in using the materials.

The person who assists them need not be technically competent in the particular subject but should understand the mechanical and procedural steps in the use of programed materials generally and be willing and able to encourage the learner by answering his questions at any stage in the use of the programed material. It is for this reason that the library is the ideal location for the study area for programed learning.

To provide sufficient space, materials, and personnel in the library to accommodate pretechnical students encourages the student to frequent the library; however, the programed learning materials area in the library will also be used by regular technical curriculum students. It has been found to be a constructive psychological factor when pretechnical students use the programed learning study area and find other regular technical students there solving problems in a similar manner.

If the library does not have this programed learning area when a pretechnical program is begun, it should be provided—preferably in the library or some other suitable study room—with an attendant who can assist the students. An initial expenditure of $1,500 to $2,000 should be planned for the acquisition of suitable programed learning materials in addition to an appropriate annual budget to keep it up to date. Adequate staff for the area is important.

Some institutions may already have a programed learning area (as part of their library or otherwise) for adult basic education or employed adult up-grading study. In such cases, it is essential that sufficient materials and space are available to serve all, including the pretechnical students. This programed learning facility should be considered as ancillary to the special study skills laboratory and cannot be substituted for it.

The Study Skills Laboratory

A well-equipped special laboratory with sufficient facilities for *all students to use the equipment and instructional reading apparatus is indispensable* for the pretechnical course in basic study skills. Variety and quality in the equipment and materials are essential for the master teacher who guides the students in practicing their skills.

The basic study skills laboratory is provided primarily for intensive remedial reading study and is the one special facility required for pretechnical post high school programs. It can be located in any building, preferably convenient to the library and easily accessible to students and teachers.

Figure 8 shows an example of a study skills laboratory. A well-lighted, pleasant, and uncrowded facility with an acoustical ceiling and draperies to provide minimum sound levels is recommended.

It should be equipped with environmental control and designed for maximum flexibility and variable use of space. In geographic areas where extremes of warm weather and high humidity prevail during that part of the year when the facilities are used, air conditioning is almost a necessity. To permit different arrangements as indicated in room 1, figure 8, normal utilities should be provided and electrical outlets should be distributed for maximum flexibility in the use of space as in both rooms 1 and 3 in figure 8.

The arrangement shown for group instruction in room 1, figure 8—the projection equipment in the middle of one end of the room slightly back of the students at the tables—permits the use of a screen lowered over a chalkboard when it is needed and raised to permit use of the chalkboard. This arrangement has been found to be effective and affords easy flexibility so that a variety of teaching techniques may be used.

Portable tables permit variety in seating arrangements to suit the needs of instruction and avoid the regimentation of a permanently fixed seating arrangement.

Cabinets sufficient in size, style, and number to satisfy storage requirements should be selected and should permit ready storage for apparatus or equipment not in immediate use.

The office and storeroom (room 3 in figure 8) should be equipped so that some of the equipment needed in the classroom and the laboratory may be stored there. It may also serve as an instructor's office and a working area where instructors can create transparencies or other instructional materials for the course. Individual conferences may be held there; tests may be given; or it may serve other functions demanded in the pretechnical program. A desk, chairs for the instructor and two or three students or others, a work table, storage racks for equip-

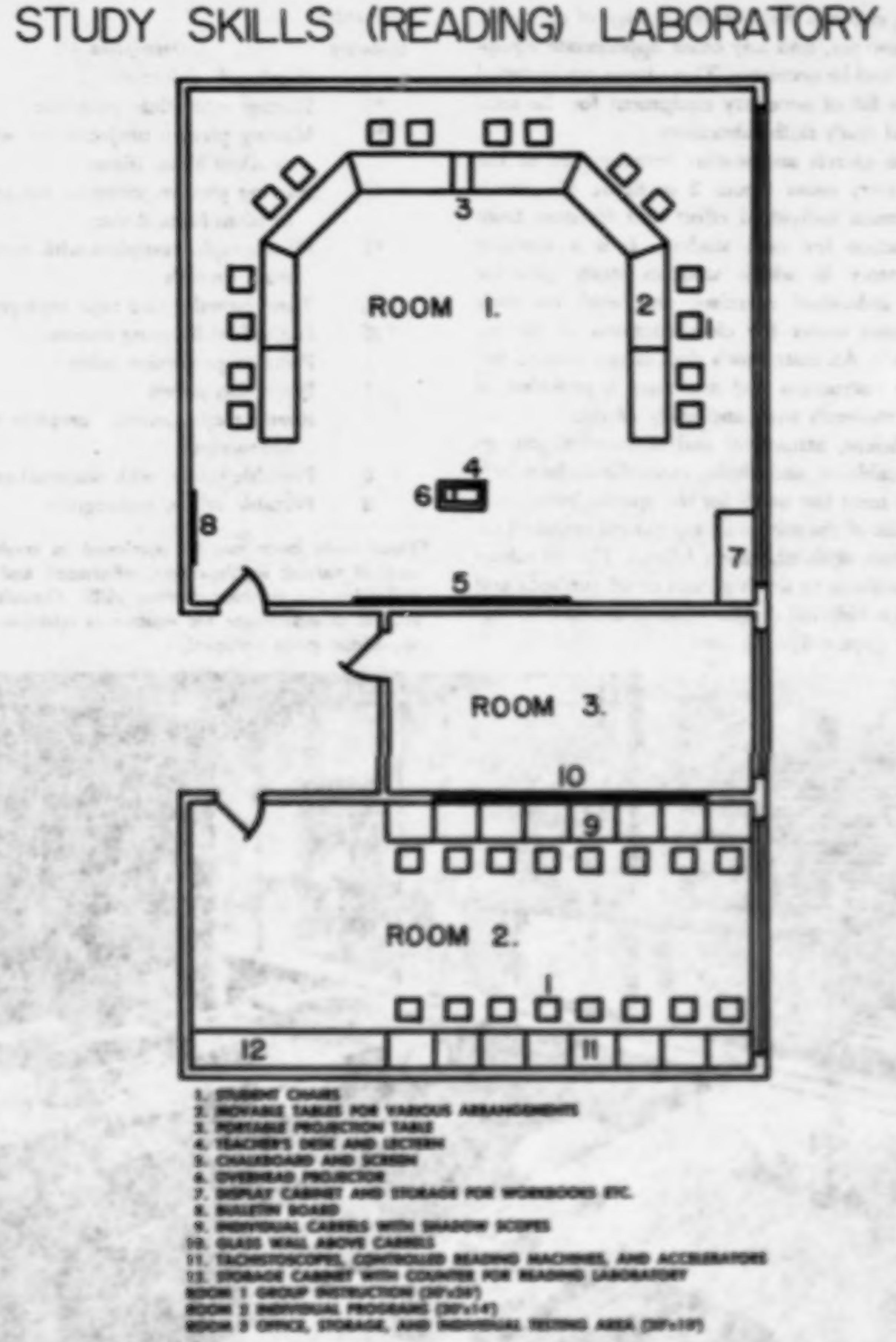
STUDY SKILLS (READING) LABORATORY
ROOM 1.
ROOM 2.
ROOM 3.
1
2
3
4
5
6
7
8
9
10
11
12
1. STUDENT CHAIRS
2. MOVABLE TABLES FOR VARIOUS ARRANGEMENTS
3. PORTABLE PROJECTION TABLE
4. TEACHER'S DESK AND LECTERN
5. CHALKBOARD AND SCREEN
6. OVERHEAD PROJECTOR
7. DISPLAY CABINET AND STORAGE FOR WORKBOOKS ETC.
8. BULLETIN BOARD
9. INDIVIDUAL CARRELS WITH SHADOW SCOPES
10. GLASS WALL ABOVE CARRELS
11. TACHISTOSCOPES, CONTROLLED READING MACHINES, AND ACCELERATORS
12. STORAGE CABINET WITH COUNTER FOR READING LABORATORY
ROOM 1 GROUP INSTRUCTION (30'x24')
ROOM 2 INDIVIDUAL PROGRAMS (30'x14')
ROOM 3 OFFICE, STORAGE, AND INDIVIDUAL TESTING AREA (20'x10')

FIGURE 8. An example of a study skills (reading) laboratory for improving study and reading skills for underprepared student technicians.

ment, cabinets and files for storage of materials, a typewriter, and any other appropriate equipment will be necessary. These items are included in the list of necessary equipment for the total special study skills laboratory.

The carrels and seating arrangement in the *laboratory room* (room 2 in figure 8) permit maximum individual effort and freedom from distraction for each student. It is a working laboratory in which students study, practice their individual exercises, and work on their problems under the close attention of the instructor. An instructor's desk is not needed because instruction and assistance is provided at each student's work and study carrel.

Efficient, attractive, and economical storage files, cabinets, and display cases should be selected to meet the needs for the special laboratory.

A list of the minimum equipment required for the study skills laboratory follows. The list allows for facilities to teach groups of 16 students and also for individual instruction of another 16 students (figure 8).

EQUIPMENT

Quantity	*Description*
1	Overhead projector
*1	Photographic slide projector
*1	Moving picture projector for sound or silent films, 16mm.
*1	Moving picture projector for sound or silent films, 8 mm.
*1	Phonograph, complete with reading study records
*2	Tape recorder and tape replayer
*16	Individual listening stations
1	Portable projection table
1	Projection screen
1	Reading eye camera, complete with accessories
6	Portable tables, with diagonal end
8	Portable tables, rectangular

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*These basic items may be purchased in combined units of varying sophistication, refinement, and specialization for teaching reading skills. Consult the general considerations for equipment selection and acquisition given previously.

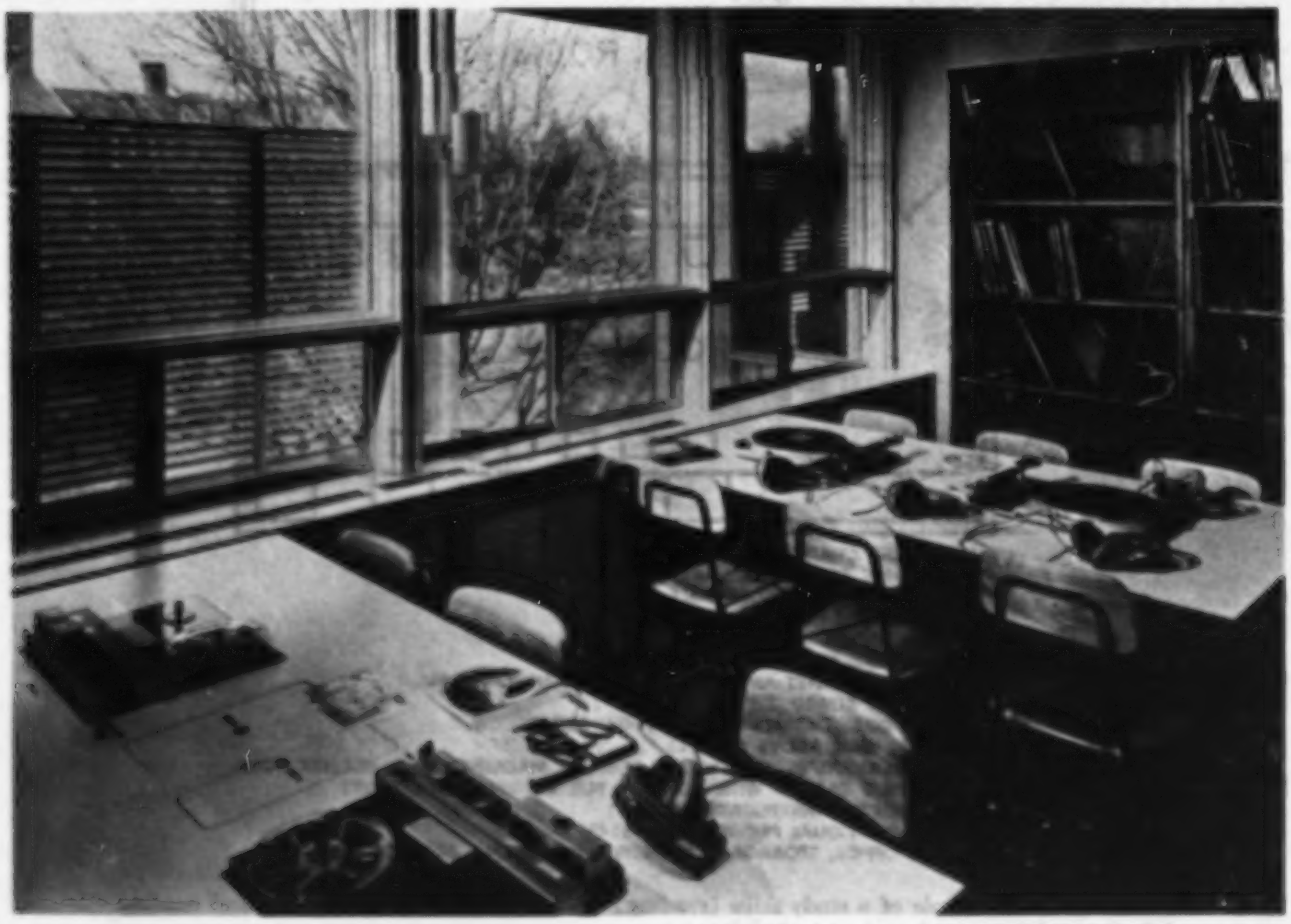

FIGURE 9. Study skills (reading) laboratories make use of the most modern learning and teaching devices. The listening units shown here can be used individually or for group instruction.

Quantity	*Description*
6	Storage cabinets
1	Storage cabinet, with counter
2	Equipment storage racks
4	Filing cabinets, 5 drawer
36	Students' chairs
2	Instructors' desks
2	Instructors' chairs
1	Lectern
1	Electric typewriter
1	Typewriter stand
1	Typewriter chair
1	Bulletin board
10	Tachistoscopes (or equivalent) with filmstrips for controlled reader tachistoscopes
8	Controlled reading machines
16	Reading accelerators
16	Individual study carrels, with shadow scopes
2	Automatic timer, 10" to 12" in diameter
4	Stop watches
300	SRA Reading records (or equivalent)
40	SRA Diagnostic Tests, Forms A and B (or equivalent)
1	SRA Reading Laboratory Set (or equivalent)
36	Advanced diagnostic tests
36	Study skills tests
16	Study skills kits
EXPENDABLE SUPPLIES	
2,500	SRA (or equivalent) Record Answer Sheets
2,500	SRA (or equivalent) Reading record profiles
2,500	Daily work sheets
2,500	Progress records
2,500	Diagnostic reading test answer sheets
500	Manila folders
	Assorted projection lamps
	Assorted other supplies to make overhead projector transparencies, plus stationery, work paper, and similar office supplies.

Total estimated cost: $25,000 to $30,000.

Cost Summary

The following cost summary for facilities is considered a reasonable minimum for a beginning pretechnical post high school program, assuming that classroom and laboratory space is available except for the study skills laboratory.

Physical facility	*Estimated cost*
Special study skills (reading) laboratory	$25,000 to $30,000
Library materials acquisition	2,000 to 2,500
Programed instructional materials area (for individual outside study)	1,500 to 2,000
Total	$28,500 to $34,500

The foregoing does not include building cost. If construction is necessary to begin the program, its cost may be calculated at $14 to $16 per square foot.

Additional Staff Required

Additional permanent full-time staff will be required to establish a pretechnical program if it is to offer a significant and continuing service to students and the institution. For administrative planning, approximately 125 students with varying needs may be considered a reasonable expectation.

Assume:

100 students who need communication skills, study skills, mathematics, and science (physics, chemistry, or biology).

25 additional students who need only mathematics and physics or chemistry.

20 hours a week of student contact as maximum teaching load.

Required teaching staff would be:

Communications—25 students/section
4 sections, 3 hours/week = 12 hours
Study Skills—16 students/section
6 sections, 2 hours/week class
2 hours/week laboratory = 24 hours

Since communications and study skills are somewhat related, a study skills teacher could teach part of the communications, but a total of *two* teachers are required for these courses for 100 students.

Mathematics—25 students/section
4 hours/week, 5 sections = 20 hours
One teacher is required.
Science (physics or chemistry) — 25 students/section
5 sections, 4 hours/week class = 20 hours
4 hours/week laboratory = 20 hours

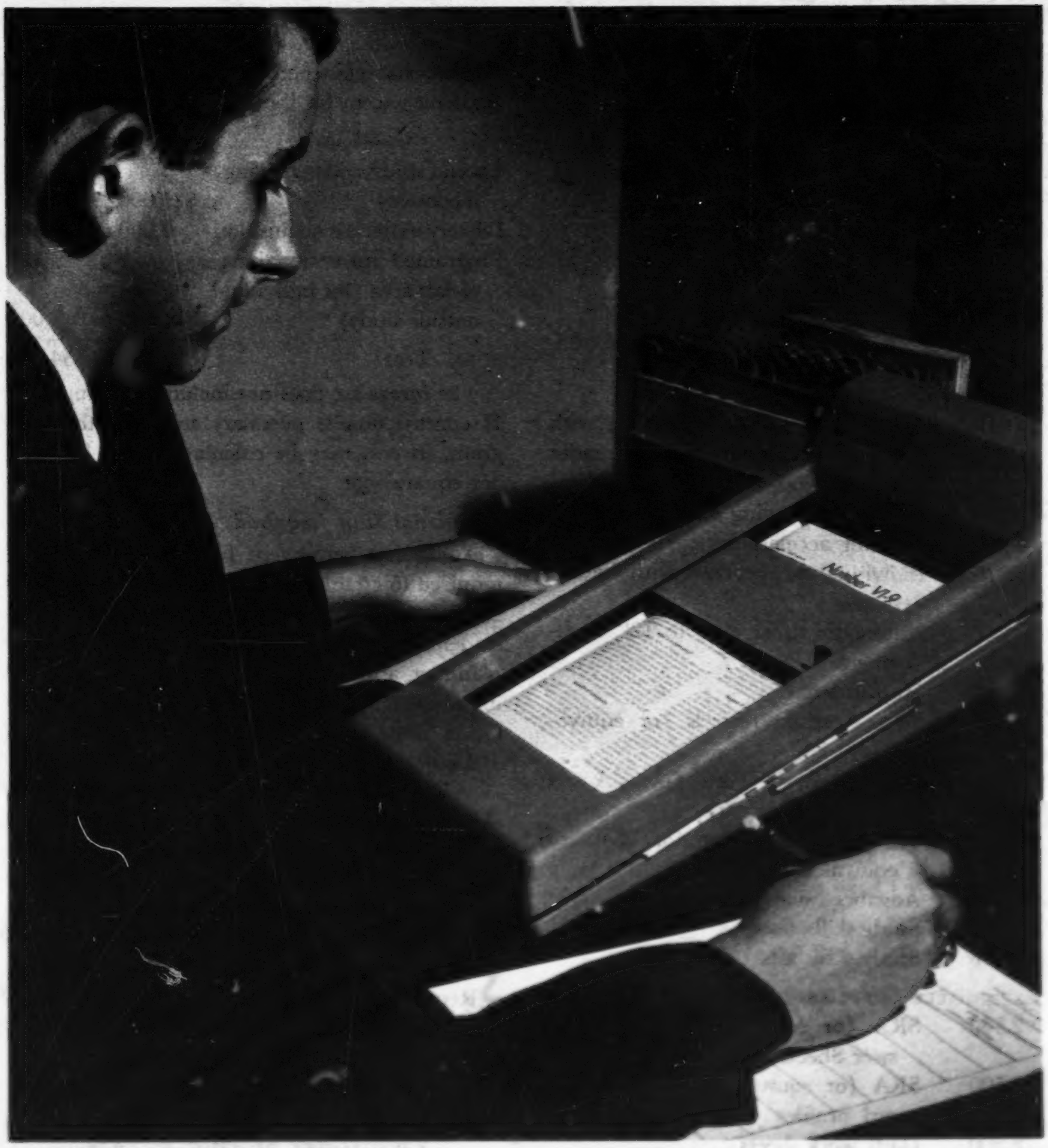

FIGURE 10. Individual instructional equipment such as this portable reading pacer is required for each student in an adequately equipped study skills remedial reading laboratory.

Two teachers are required—one physics and one chemistry or as situation requires.

If biological science is a prerequisite for curriculums in the institution, 1 section of 25 students may be required for 3 hours/week class, 4 hours/week laboratory totaling 7 hours. This probably could be taught by the biological science instructor already in the institution, but his load would have to be adjusted to the recommended maximum of 20 student contact hours.

Summary:

Total additional teaching staff	5
Additional special counselors	2
Library service or special person with equivalent training for the programed instruction study area. .	1
Total	8

COURSE OUTLINES

The course outlines in the following pages are designed to provide the student with a confident understanding of the knowledge and skills equivalent to or above successful mastery of the subject *at the high school level.*

The procedures employed in teaching these subjects to pretechnical students must be to (1) assess the amount of subject knowledge and skill of each individual student and (2) teach the subject as nearly as possible on an individual basis, starting where the student's knowledge begins and helping him master the subject to the point where study begins in the first semester of the regular technician curriculum.

Experience shows that the teachers of all pretechnical courses can be most successful in helping students master the required level of the subject matter if they relate their teaching to the particular technology chosen by each student as a major interest and scholastic objective.

The required depth of coverage to be attained in pretechnical courses is equivalent to above average high school mastery of the subject. The teachers must constantly be aware of the pretechnical course as providing a foundation of knowledge, understanding, confidence, and skill in a subject which will be extended in the following semesters of the technical curriculum.

The courses which follow are suggestions for the content which might be taught in the program. The materials included present a practical and attainable coverage of the field and have been reviewed by experienced instructors and administrators of successful pretechnical programs and by experts in high school administration, technical education, and counseling and guidance.

It is expected that these materials will be modified in some measure to fill the needs defined by local advisory committees and to take advantage of special interests and capabilities of the teaching staff in any particular institution. Even so, the implied level, quality, and completeness of the program should not be compromised.

At the end of each course is a list of text and reference materials. Each should be analyzed for its content and relativity to the course; new and more suitable references should be substituted if they are available. The information needed to cover a particular course in a pretechnical program is almost never available in one textbook—hence the multiple listing of references. They usually should be augmented by current materials, especially visual and audiovisual aids (see Appendix C).

Visual aids should be used whenever pertinent to make teaching more efficient. *Excessive showing of films at the expense of well-prepared class and laboratory exercises is to be avoided.* Outside study periods may be used instead of class lecture time for showing some films and for using individual programed learning materials. All visual aids should be previewed by the instructor before they are shown.

The experienced instructor will probably make liberal use of charts, slides, models, samples, and specimens to illustrate special aspects of a subject. These are usually accumulated by the instructor from previous laboratory or class preparations but should be updated regularly. They are too specific to be listed in this guide.

It should be noted that examinations have not been scheduled in the course outlines even though it is clearly intended that time be allowed for examinations. Therefore a 17-week semester is assumed, but the outlines are designed to cover 16 weeks. Examinations are necessary to evaluate the student's knowledge and to cause him to make a periodic comprehensive review of the material presented in the course.

STUDY SKILLS

HOURS REQUIRED

Class, 2; Laboratory, 2

Description

The objective of this course is to help the student develop the fundamental learning skills necessary for effective scholastic accomplishment at a college level. Most of the skills depend on reading speed and comprehension and a mature interpretation and use of written and oral communication skills. Reading improvement exercises are conducted during the 2-hour laboratory sessions. This provides the necessary time for the student to practice reading improvement with machines, visual aids, and other recommended media. Listening and study aids in the library should also be used to supplement the equipment of the learning laboratory.

The course outline is developed showing separate divisions of subject matter for class work and laboratory sessions.

A concerted effort should be made not to duplicate in the study skills course those areas of improvement that can better handled by the course in communication skills — such as spelling, punctuation, and the mechanics of writing and/or speaking in general. As much as possible each student should be given individual instruction in the classroom.

Major divisions	*Class hours*
I. Development of Attitudes	2
II. Scheduling Time and Working Effectively	3
III. Using Textbooks Properly	5
IV. Taking and Organizing Notes	5
V. Use of the Library and Its Facilities	4
VI. Improving Concentration and Memory	3
VII. Writing Reports and Research Papers	4
VIII. Effective Examination Skills	4
IX. Reading Improvement	2
Total	32

I. Development of Attitudes
  1. Self-realization of definite goals
    a. Clarifying vocational aims
    b. Self-assessment of student's strong and weak points
  2. Making realistic decisions
    a. Selecting programs and curriculums
    b. Evaluating goals "realistically"
  3. Evaluating interest and abilities
    a. What is academic success
    b. What is vocational success

II. Scheduling Time and Working Effectively
  1. Setting up a work schedule
    a. When to study
    b. How much time to study; allocating time
    c. Fitting the schedule to individual routines and individual differences
    d. The value of rest periods
    e. Revising the schedule
  2. The study environment
    a. Where to study
    b. Physical surroundings
    c. Light, ventilation, and noise

III. Using Textbooks Properly
  1. Common approaches
    a. P, Q, R, S, T or SQ3R methods as examples
    b. Underlining
    c. Skimming and scanning
    d. Charts, graphs, maps, and diagram interpretations
    e. Summarizing chapters
  2. Different types of reading
    a. To master information
    b. Exploratory for general views
    c. Reviewing
    d. Searching out information
    e. Critical reading
  3. Demonstrations of methods
    a. Student applications
    b. In class practices

IV. Taking or Organizing Notes
  1. Reasons for taking notes
  2. Types of notes
    a. Verbatim
    b. Outline notes
    c. Skeleton outlines
  3. Interpretive listening
    a. Accenting important points
    b. Knowing instructor traits
    c. Adjusting to different types of lectures
  4. Making notes on reading assignments

5. Reorganization of notes; use of colored marking on notes to accent points
6. Outlines
    - a. Standard outline procedures
    - b. Abbreviating
7. In-class practice on note taking and outlining
8. Reviewing notes; when to review

V. Use of the Library and Its Facilities
1. Becoming acquainted with library facilities; class visits
2. Investigating reference materials
    - a. Statistical references
    - b. Biographical information
    - c. Encyclopedias
    - d. Periodicals
    - e. Abstracts
    - f. Micro-film machines
    - g. Card catalog
3. Becoming acquainted with library rules and etiquette
4. Services the librarian can provide
5. Use of central lending libraries for securing unusual material; procedures for securing library service
6. Practical application of the use of the library through assigned research projects

VI. Improving Concentration and Memory
1. The psychology of learning
    - a. The memory process
    - b. Over-learning
    - c. Association
2. Factors affecting learning
    - a. Motivation
    - b. Comprehension
    - c. Organization
    - d. Repetition
3. Concentration
    - a. Attention span
    - b. Distractions
        - (1) Psychological
        - (2) Physical
    - c. Establishing study habits
        - (1) Routine
        - (2) Atmosphere and physical surroundings

VII. Writing Reports and Research Papers
1. Selecting topics; importance of choice
    - a. Interest to the reader
    - b. Is information available on the topic
    - c. Is the topic too broad
2. Locating sources of information
    - a. Library sources
    - b. Surveys
3. Collecting and recording data or information
    - a. Brief notes
    - b. Index cards
    - c. Keeping a record of reference sources
4. Organization of material
    - a. Topics
    - b. Subtopics
5. Developing an outline
    - a. Importance of outlining material
    - b. Writing the draft from the outline
    - c. Revisions
6. Proofreading
    - a. With another person
    - b. Sticking to the point
    - c. Checking mechanics and spelling
7. Practice in writing a paper
    - a. Selecting the topic
    - b. Researching the topic
    - c. Outlining the topic
    - d. Writing the rough draft
    - e. Writing the final draft

VIII. Effective Examination Skills
1. Preparing for examinations
    - a. Understanding what will be covered
    - b. Setting up a definite study
    - c. Predicting examination questions
    - d. Rest and proper attitude
2. Reviewing
    - a. Organizing material
    - b. Making use of flash cards, underlinings, and main headings
    - c. Reviewing in groups
3. Objective-type examinations
    - a. Scanning the test

    - b. Reading the directions
    - c. Planning available time
    - d. Helpful hints
- 4. Essay examinations
    - a. Planning available time
    - b. Outlining the approach by noting main ideas
    - c. Making answers specific
    - d. "Padding" questions; right or wrong
    - e. Staying on the topic
    - f. Writing legibly

IX. Reading Improvement

The objective of this division is to offer either large or small group instruction to those students with common reading difficulties. Individual attention must be given to all, especially to those with serious reading problems. The distribution of laboratory time showing subjects and hours might be:

LABORATORY—32 hours

	Subject	*Laboratory hours*
1.	Diagnostic testing	1
2.	Word recognition	4
3.	Speeded comprehension of paragraphs	10
4.	Speeded comprehension of small units	6
5.	Speeded comprehension of connected text	10
6.	Achievement testing	1
	Total	32

NOTE: Franklin Reading Pacers, S.R.A. Reading Accelerators, E.D.L. Tach-X tachistoscope, and E.D.L. controlled Readers can be used in addition to the S.R.A. Laboratory Secondary Edition.

Texts and References

Baker. *Reading Skills*
Cosper and Griffin. *Toward Better Reading Skill*
Crow and Crow. *How to Study*
Farquhar and others. *Learning to Study*
Maddox. *How to Study*
Miller. *Increasing Reading Efficiency*
Morgan and Deese. *How to Study*
Spache and Berg. *The Art of Efficient Reading*
Staton. *How to Study*

PREPARATORY COMMUNICATION SKILLS I AND II

HOURS REQUIRED

Class, 3 (two semesters)

Course Description

Preparatory Communication Skills is designed to assist the student in improving his written and oral expression through an intensive study of the mechanics of the language. The fundamentals of grammar, punctuation, spelling, vocabulary, sentence structure, and paragraphs constitute the content of the course. The major emphasis is practice and analysis of written expression.

The work in this course should be closely coordinated with the concurrent Study Skills course so that one strengthens the other.

(This course, while designed for two semesters, may be selectively shortened to a 5-hour per week, one-semester course for more advanced students.)

	Major divisions	*Class hours*
I.	How to Study	6
II.	Improving Reading Ability	20
III.	Improving Spelling and Vocabulary	24
IV.	Improving Writing Ability	30
V.	Talking and Listening	16
	Total	96

I. How to Study
- 1. Orientation to course
    - a. Reading
    - b. Writing; paragraph submitted
    - c. Assignments
- 2. PQRST method of study
- 3. The learning process
- 4. Tools of learning
- 5. Tips on learning
- 6. Review and testing

II. Improving Reading Ability
- 1. Visual analysis
    - a. Number recognition
    - b. Letter recognition
    - c. Word recognition
- 2. Timed comprehension
    - a. Word meanings
    - b. Phrases

    - c. Sentences
    - d. Directions

III. Improving Spelling and Vocabulary
  1. Spelling lists and exercises
     - a. Mimeographed material
     - b. Exercises
     - c. Testing
  2. Vocabulary
     - a. Introduction of words
     - b. Exercises in vocabulary
     - c. Testing

IV. Improving Writing Ability
  1. Paragraph patterns
  2. Paragraph completeness and terseness
  3. Paragraph unity
  4. Paragraph coherence
  5. Paragraph developed by example
  6. Paragraph developed by comparison or contrast
  7. Paragraph developed by facted details
  8. Sentence skeletons
  9. Modifiers
  10. Simple sentence with compound elements
  11. Simple sentence with appositives
  12. Simple sentence with verbal phases
  13. Simple sentences with appositives and participial phrases
  14. Agreement of subject and verb
  15. Clauses
  16. Complex sentences with noun clauses
  17. Complex sentences with adjective clauses
  18. Complex sentences with adverbial clauses
  19. Sentence fragments
  20. Compound sentences with coordinating conjunctives
  21. Compound sentences with logical connectives
  22. Review and testing

V. Talking and Listening (emphasis on student exercises)
  1. Diagnostic testing
  2. Organization of topics or subject
  3. Directness in speaking
  4. Gesticulation and use of objects to illustrate
  5. Conversational courtesies
  6. Listening faults
  7. Taking notes
  8. Understanding words through context clues
  9. Exercises in talking and listening

Texts and References

Baird and Knower. *Essentials of General Speech*

———. *General Speech, An Introduction*

Beardsley. *Thinking Straight: Principles of Reasoning for Readers and Writers*

Blumenthal. *English 2200: A Programmed Course in Grammar and Usage*

Bordeaux. *How to Talk More Efficiently*

Cowan and McPherson. *Plain English Please*

De Vitis and Warner. *Words in Context: A Vocabulary Builder*

Funk. *Six Weeks to Words of Power*

Lee. *Language Habits in Human Affairs: An Introduction to General Semantics*

Ostrom. *Better Paragraphs*

Roget. *New Roget's Thesaurus*

Webster's New Seventh Collegiate Dictionary

Zetler and Crouch. *Successful Communication in Science and Industry: Writing, Reading and Speaking*

PREPARATORY MATHEMATICS I

HOURS REQUIRED

Class, 4 (one semester)

Description

This course, Preparatory Mathematics I, is the first of a series of two courses designed to furnish the mathematical foundation for students entering either a biological science technology or those who will enter a physical science or engineering related technology. When entire classes are compiled of students preparing for biological science technologies, the first semester course may be sufficient to meet the prerequisite mathematical needs for entering the first-year courses in the technical curriculums.

In conducting a course following this outline, stress should be placed on the understanding of basic principles as well as mastery of mechanical procedures. Ample problem solving should be incorporated to insure mastery of mechanical procedures by the student. The arrangement of topics may be altered to suit particular class needs.

This course has been designed so that only an understanding of arithmetic is necessary as a prerequisite. The class hours assigned each topic are suggested as guides and may be adjusted to suit the backgrounds of the students.

Frequent testing is recommended throughout this course. It is suggested that short tests be given rather than long examinations. This provides more opportunity for the student to evaluate his progress and make satisfactory adjustments. Outside study problems should be a regular part of the course. Students should be required to use the slide rule whenever possible and to become proficient in its use.

Major divisions	Class hours
I. Introduction and Diagnostic Testing	2
II. Operation with Numbers	7
III. Conversions	2
IV. Slide Rule	2
V. Ratio Proportion and Percentage	3
VI. Exponents and Radicals	4
VII. Logarithms	4
VIII. Operations of Algebra	10
IX. Solving Linear Equations	5
X. Factoring	10
XI. Solution of Linear Equation Systems	3
XII. Graphical Representation	5
XIII. Trigonometric Functions and Uses.	5
Total	64

I. Introduction and Diagnostic Testing

1. Diagnostic testing
2. Value and use of mathematics in the technologies
3. An effective approach to the study of mathematics

II. Operations with Numbers

1. Fundamental symbols of arithmetic
2. Signed numbers
3. Rules for multiplying or dividing by zero and one
4. Addition, subtraction, multiplication, and division of signed numbers
5. Short cuts in arithmetical operations
6. Fractions
    a. Addition, subtraction, multiplication, and division
    b. Reducing of fractions
    c. Determining the lowest common denominator
7. Decimal
    a. Decimal notation
    b. Addition, subtraction, multiplication, and division of decimal numbers
    c. Expressing fractions as decimals
    d. Complex fractions
8. Significant numbers and rounding off

III. Conversions

1. Common units and systems
2. Metric system
3. Problems using conversions

IV. Slide Rule

1. Reading the scale
2. Operations
    a. Multiplication
    b. Division
    c. Combined multiplication and division

V. Ratio, Proportion and Percentage

1. Use
2. Ratio and measurement
3. Proportion
4. Percentage and percent
5. The percentage formula
6. Problems on conversion, etc., for slide rule

VI. Exponents and Radicals

1. General exponents laws
2. Standard notation
3. Radicals
4. Simplification of radicals
5. Adding, subtracting, multiplying, and dividing radicals
6. Practice in handling fractional exponents
7. Use of slide rule in handling exponents and radicals
8. Problems to exemplify principles

VII. Logarithms

1. Definition of logarithm
2. Common logarithms

3. Method of determining logarithms of numbers
4. Interpolation
5. Laws of logarithms
6. Use of slide rule in handling logarithms
7. Problems to exemplify principles

VIII. Operations of Algebra
1. Addition and subtraction of algebraic expressions
2. Laws governing use of parenthesis (or brackets)
3. Laws of exponents in algebra
    - a. $a^n \cdot a^m$
    - b. $a^n \div a^m$
    - c. $(a^n)^n$
    - d. $(ab)^n$
    - e. $\left(\frac{a}{b}\right)^n$
4. Multiplication and division of algebraic expressions
    - a. Multiplying a monomial by a monomial
    - b. Multiplying a polynomial by a monomial
    - c. Multiplying a polynomial by a polynomial
    - d. Removing a parenthesis
    - e. Dividing a monomial by a monomial
    - f. Dividing a polynomial by a monomial
    - g. Dividing a polynomial by a polynomial
    - h. The square of the sum of two quantities
    - i. The square of the difference of two quantities
    - j. The cube of the sum of two quantities

IX. Solving Linear Equations
1. Procedure for solving linear equations
2. Solving literal equations and formulas—equations containing parentheses or fractions, and requiring transposition
3. Verbal problems
4. Problems of ratio, proportion, and percentage

X. Factoring
1. Purpose of factoring
2. Common factor or highest common monomial
3. Perfect square or cubes
4. Difference of two squares
5. Factoring by groups
6. Factoring trinomials
7. Factoring completely
8. Verbal problems requiring factoring
9. Problems requiring simplification of complex fractions

XI. Solution of Linear Equations Systems
1. Solution of linear equations systems with two unknowns
2. Solution of linear equations systems with three unknowns
3. Verbal problems exemplifying principles

XII. Graphical Representation
1. Pictorial graphs
2. Bar and line graphs
3. The coordinate system
4. Graphs of linear equations
5. Slope of a line
6. Graphs of linear equation system with two unknowns

XIII. Trigonometric Functions and Uses
1. Measurement of angles
2. Degrees and radians
3. Definition of sine, cosine, and tangent
4. Solution of problems dealing with right triangle using sine, cosine, and tangent
5. Pythagorean Theorem

Texts and References

Andres and others. *Basic Mathematics for Science and Engineering*
Cameron. *Algebra and Trigonometry*
Cooke. *Basic Mathematics for Electronics*
Kaltenborn and others. *Basic Mathematics*
Mitchell and Cohen. *A New Look at Elementary Mathematics*
Rice and Knight. *Technical Mathematics*
Rider. *First-Year Mathematics for College*
Spitzbart and Bardell. *Introductory Algebra and Trigonometry*
Wade and Taylor. *Fundamental Mathematics*
Wagner. *Introductory College Mathematics*

PREPARATORY MATHEMATICS II

HOURS REQUIRED

Class, 4 (one semester)

Description

This course follows Preparatory Mathematics I and should build on it so that students may make maximum use of what they learned in Preparatory Mathematics I. It should avoid repetition of topics. Mastery of the subject matter equivalent to *above average* high school accomplishment is essential in order to successfully prepare students to enter physical science or related engineering technology programs.

The order of the topics can be flexible. However, topics which are most interesting to the students may be interspersed with mathematical exercises which tend to be less interesting. Ample time has been allowed to permit a full description of the application of each topic to a variety of the engineering-related technology subjects. Substantial outside study in problem solving should be assigned to insure that most of the mechanical procedures involved become automatic.

Each homework assignment should contain problems which will stimulate and require the student to continuously review old materials as well as current and new procedures. Frequent testing is recommended. Understanding of the use of mathematics as a tool and capability to apply mathematical principles must be emphasized.

	Major divisions	*Class hours*
I.	Quadratic Equations	12
II.	Determinates	3
III.	Geometry	10
IV.	Trigonometry	15
V.	Progression	4
VI.	Binomial Theories	3
VII.	Probability and Sampling	6
VIII.	Statistics	5
IX.	Complex Numbers	6
	Total	64

I. Quadratic Equations
  1. Definition of a quadratic equation
  2. Solution by factoring
  3. Graphical solution
  4. Solution by completion of equations
  5. Solution by quadratic formula
  6. Imaginary roots
  7. Extreme value of a quadratic function
  8. Solution of a system of equations by substitution
  9. Application of verbal problems
  10. Irrational equations

II. Determinates
  1. Solution by determinant of second order
  2. Solution by determinant of third order

III. Geometry
  1. Definition and application of congruent triangles and similar triangles
  2. Comparison of properties of parallelogram, rhombus, and square
  3. Problems involving formulas
    a. Circumference of circle
    b. Area of circle
    c. Area of three-sided figure
    d. Area of four-sided figure
    e. Area of figures having more than four sides
    f. Product of intersecting chords in a circle
    g. Equation of a circle (translation of axis)
    h. Length of tangent to circle
    i. Equation and construction of a parabola
    j. Equation and construction of an ellipse
    k. Equation and construction of a hyperbola

IV. Trigonometry
  1. Definitions of secant, cosecant, and co-tangent functions
  2. Identities
  3. Trig scales on slide rules
  4. Solution of problems with oblique triangles (applying laws of sines, cosines, etc.)
  5. Graphs of trig functions
  6. Inverse trig functions
  7. Formulas—half and double angles

V. Progressions
   1. Arithmetic progressions
   2. Geometric progressions
   3. Annuities

VI. Binomial Theorem
   1. Positive integral power
   2. The theorem and its proof
   3. Negative or fractional powers

VII. Probability and Sampling
   1. Combinations
   2. Permutations
   3. Probability
   4. The normal curve
   5. Sampling

VIII. Statistics
   1. Introduction
   2. Frequency distribution
   3. The arithmetic mean
   4. The median and mode
   5. Standard deviation
   6. Normal frequency curve and standard deviation
   7. Computation formulas

IX. Complex Numbers
   1. Graphical representation
   2. Addition, subtraction, multiplication and division of a complex number
   3. DeMoivre's Theorem
   4. Roots of a complex number

Texts and References

Andres and others. *Basic Mathematics for Science and Engineering*
Banks. *Elements of Mathematics*
Cameron. *Algebra and Trigonometry*
Cooke. *Basic Mathematics for Electronics*
Dubisch and others. *Intermediate Algebra*
Evans. *Fundamentals of Mathematics*
Heimer and others. *A Program in Contemporary Algebra*
Helton. *Introducing Mathematics*
Kaltenborn and others. *Basic Mathematics*
Mitchell and Cohen. *A New Look at Elementary Mathematics*
Mueller. *Essential Mathematics for College Students*
Rice and Knight. *Technical Mathematics*
Rider. *First-Year Mathematics for Colleges*
Sparks. *A Survey of Basic Mathematics*
Spitzbart and Bardell. *Introductory Algebra and Trigonometry*
Wade and Taylor. *Fundamental Mathematics*
Wagner. *Introductory College Mathematics*

PREPARATORY PHYSICS I

HOURS REQUIRED

Class, 4; Laboratory, 4 (one semester)

Description

This course is an elementary study of heat and mechanics designed so that the student who successfully completes it has knowledge and skills in physics equivalent to above average completion of high school physics. It does not correspond to a typical high school course. It provides the necessary basics in physics which the student needs to cope with the course in post high school technical curriculums requiring a physics background.

The suggested time for each topic should be altered if necessary to insure student mastery of the material. The time allowance for the various divisions should be maintained as nearly as possible. Frequent testing on each topic is recommended to maintain a desired level of student achievement. Many short tests are recommended to determine the level of information mastered by the student. More comprehensive tests may be used to ascertain the student's proficiency in correlating the materials of one topic with another.

A number of laboratory experiments have been listed. The instructor should select from this list those experiments which most effectively supply what the class needs to learn. As many experiments as time allows should be conducted. An occasional laboratory period may be used for the study of comprehensive problems and perhaps for comprehensive testing. Demonstrations should be given whenever possible, followed by student practice to develop laboratory skills and proficiency in the scientific method of study and inquiry.

Laboratory experiments should place emphasis on the proper techniques for handling equipment, developing orderly procedures in conducting an experiment, and systematically arranging apparatus for effective data taking. Experiments should promote questions requiring critical thinking, provide experience in handling delicate apparatus and equipment, and teach good report writing.

The purpose of the physics program is to develop an appreciation and understanding of basic fundamental principles.

Direct reference as often as possible to practical applications of physics principles will assist in maintaining student interest and understanding of the subject.

	Major divisions	*Class hours*
I.	Temperature and Measurement	4
II.	Heat and Expansion	5
III.	Heat Transfers and Calorimeters	7
IV.	Change of States	5
V.	Humidity	2
VI.	Thermodynamics	4
VII.	Mechanics of Liquids	10
VIII.	Applications of Atmospheric Pressures	4
IX.	Forces and Components	7
X.	Engineering Properties of Common Materials Subject to Mechanical Loads	3
XI.	Rectilinear Motion	3
XII.	Non-linear Motion	2
XIII.	Newton's Laws	3
XIV.	Work and Friction	5
	Total	64

I. Temperature and Measurement
   1. Temperature concepts
   2. Measurement
      a. Fundamental and derived units
      b. Metric system
      c. English system
      d. Accuracy and significant figures
   3. Density — Volume of rectangular solids
   4. Standard form for solving problems
      a. The scientific method
      b. Need for precision
      c. Use of standard units

II. Heat and Expansion
   1. Molecular theory
      a. Microscopic and macroscopic methods
      b. Types of thermometers
      c. Scales
   2. Expansion
      a. Linear expansion of solids
      b. Linear expansion of gases
      c. Gas laws
      d. Thermal stresses
      e. Coefficients of expansion of solids and gases.

III. Heat Transfer and Calorimeters
   1. Conduction—thermal resistance
   2. Convection—thermal resistance
   3. Radiation—thermal resistance
   4. The behavior of water on freezing
   5. Stefan's Law
   6. Specific heat, thermal capacitance
   7. Methods of determination for mixtures

IV. Change of State
   1. Change of phase—heats of fusion, vaporization
   2. Factors affecting melting and freezing
   3. Factors affecting evaporation and condensation
   4. Effect of pressure
   5. Refrigeration

V. Humidity
   1. Absolute
   2. Relative
   3. Measurement
   4. Effect on comfort
   5. Dew point
   6. Evaporation and boiling

VI. Thermodynamics
   1. Mechanical equivalent
   2. Heat of combustion
   3. Heat engines

VII. Mechanics of Liquids
   1. Pressure in a fluid
   2. Pressure due to gravity
      a. Depth and density
      b. Independent of shape
      c. Vertical surfaces
   3. Distribution of Pressure
      a. Pascal's Law
      b. Hydraulic press
   4. Buoyancy
      a. Archimedes' Law
      b. Floating bodies
      c. Specific gravity of solids and liquids
      d. Use of hydrometer
      e. Surface tension

VIII. Applications of Atmospheric Pressures
   1. Barometer
   2. Aneroid barometer
   3. Archimedes' principle with air
   4. Force and lift pumps
   5. Manometers and pressure balance devices
   6. Siphon
   7. Bernoulli principle
   8. Venturi meters
   9. Laminar and turbulent flow

IX. Forces and Components
   1. Forces, components, resultants, parallelogram of forces
   2. Simple force systems,— conditions and axioms of static equilibrium
   3. Free body diagrams, force analysis
   4. Moment of force

X. Engineering Properties of Common Materials Subject to Mechanical Loads
   1. Rigidity, moduli of elasticity
   2. Tensile, shear, and compressive strengths
   3. Hardness
   4. Temperature effect on properties
   5. Fatigue
   6. Effect of shape on resistance to deformation

XI. Rectilinear Motion
   1. Constant forces
   2. Speed, acceleration, and distance formuli

XII. Non-linear Motion
   1. Projectile motion
   2. Circular motion

XIII. Newton's Laws
   1. Law of Gravitation
   2. Newton's First and Second Laws
   3. Newton's Third Law

XIV. Work and Friction
   1. Work—force, distance
   2. Kinetic energy, momentum, impulse, and reaction
   3. Potential energy
   4. Power

LABORATORY—64 hours

Two 2-hour laboratory periods each week are recommended. The list of experiments presented here is only a guide. Laboratory experiments should be selected by the instructor which meet the needs of the class and cover the fundamentals taught in this course. Each student should be required to keep a laboratory notebook.

Experiments which provide laboratory experience for each student in the following subject areas should be performed:

1. Precision measurement
2. Gas thermometer
3. Study of a thermocouple
4. Change of state—latent heat
5. Heat measurement—specific heat
6. Archimedes' Principles
7. Specific gravity
8. Boyle's Law of Gases
9. Force and motion
10. Newton's Laws of Motion
11. Equilibrium of concurrent forces
12. Equilibrium and the principles of moments
13. Simple harmonic motion

Texts and References

Blackwood and others. *General Physics*
Durbin. *Introduction to Physics*
Greene. *Principles of Physics*
Harris and Hemmerling. *Introductory Applied Physics*
Humphreys and Beringer. *First Principles of Atomic Physics*
Pollack. *Applied Physics*

PREPARATORY PHYSICS II

HOURS REQUIRED

Class, 4; Laboratory, 4 (one semester)

Description

This course is a continuation of Preparatory Physics I. It completes the elementary study of mechanics and continues with the study of light, sound, and elementary electricity.

Since the material of this course will provide understanding for further in depth technical studies, careful planning is necessary so that the student will master all of the subject matter. Teaching emphasis should be on underlying principles and should use laboratory equipment and experiments which will result in maximum learning.

As many laboratory experiments as time permits should be selected from the accompanying list. Experiments should be selected which provide learning experiences most needed by each identifiable group of pretechnical students in the class.

Major divisions		*Class hours*
I.	Simple Machines	2
II.	Centrifugal and Centripetal Forces	1
III.	Simple Harmonic Motion	2
IV.	Illumination	1
V.	Reflection	2
VI.	Refraction	2
VII.	Lenses and Optical Instruments	2
VIII.	Nature and Transmission of Sound	2
IX.	Reflection of Sound	1
X.	Intensity, Loudness, and Resonance	3
XI.	Musical Sounds and Instruments	2
XII.	Ohm's Law and Resistance Calculations	4
XIII.	Series and Parallel Circuits	3
XIV.	Networks	3
XV.	Magnetic Fields and Inductance	3
XVI.	Meters	3
XVII.	The Sine Wave	2
XVIII.	Alternating Current Series Circuits	5
XIX.	Alternating Current Parallel Circuits	5
XX.	Polyphase Systems	2
XXI.	Vacuum Tubes	3
XXII.	Power Supplies	2
XXIII.	Amplifiers	2
XXIV.	Tuning Circuits	3
XXV.	Electronic Applications	4
	Total	64

I. Simple Machines
  1. Incline plane, screw, lever, pulley
  2. Input, output
  3. Mechanical advantage
  4. Efficiency
  5. Applications

II. Centrifugal and Centripetal Forces

III. Simple Harmonic Motion
  1. Rotary motion, speed, acceleration
    a. Radian measurement
    b. Moment of inertia
    c. Radius gyration
  2. Straight-line motion
  3. Restoring forces
  4. The pendulum

IV. Illumination
  1. Candle power
  2. Foot candle
  3. Photometers
  4. Room illumination

V. Reflection
  1. Law of
    a. Plane mirrors
    b. Curved mirrors
  2. Applications

VI. Refraction
  1. Cause
  2. Index
  3. Parallel and non-parallel surfaces
  4. Total internal refraction
  5. Prisms

VII. Lenses and Optical Instruments
  1. Convex lenses
  2. Focal point and focal length
  3. Image formation
  4. Concave lenses
  5. Magnifying glass
  6. Telescope
  7. Microscope
  8. Opera glass
  9. Camera
  10. Eye
  11. Condensing Systems

VIII. Nature and Transmission of Sound
  1. Origin in vibrating bodies
  2. Transverse and longitudinal waves
  3. Velocity; frequency; wave length; amplitude
  4. Velocity in various media

IX. Reflection of Sound
  1. Echoes
  2. Reverberations
  3. Acoustics

X. Intensity, Loudness and Resonance
  1. Bel

2. Effect on frequency
3. Audibility
4. Resonance in closed tubes
5. Resonance in open tubes
6. Sympathetic vibrations (resonance)

XI. Musical Sounds and Instruments
1. Pitch
2. Quality
3. Loudness
4. Harmony beats
5. String instruments
6. Air column instruments

XII. Ohm's Law and Resistance Calculations
1. Definition of amperes, ohms, volts
2. Ohm's Law
3. Resistance calculations
4. Effect of temperature on resistance
5. The wire tables
6. Insulations

XIII. Series and Parallel Circuits
1. Properties of series circuits
2. Properties of parallel circuits
3. Circuit analysis by assuming current and voltage
4. Potential differences in networks
5. Voltage dividers
6. Three-wire circuits

XIV. Networks
1. Loop analysis—Kirchoff's Law
2. The Superposition Theorem
3. Nodal analysis
4. Thevenin's Theorem

XV. Magnetic Fields and Inductance
1. Field around an electric current
2. Magnetism
3. Fields around bar magnets
4. Electro magnets
    a. Effect of core materials
    b. Effect of number of turns
    c. Effect of current magnitude
5. Induction—2 or more coils
6. Condenser action
7. Condenser in series and parallel

XVI. Meters
1. The ballistic galvanometer
2. The D'Arsonval Meter Movement
3. Ammeters
4. Voltmeters
5. Ohmmeters
6. Iron vane movements
7. Electro-dynamometer movement
8. Wattmeters

XVII. The Sine Wave
1. Generation of a Sine Wave
2. The average and effective values
3. Phase angle, power, and power factor
4. Voltage and current relationship for resistive, inductive, and capacitive circuits

XVIII. Alternating Current Series Circuits
1. Vector-phasor diagrams
    a. Resistive load only
    b. Resistive and inductive units in series
    c. Resistive and capacitive units in series
    d. Resistive, capacitive, and inductive units in series
2. Series resonance
3. Effect of frequency, inductance, and capacitance on resonance
4. Problems

XIX. Alternating Current Parallel Circuits
1. Resistances in parallel
2. Resistances and inductances in parallel
3. Resistances and condensers in parallel
4. Inductances and capacitors in parallel
5. Parallel resonance
6. Power factor correction

XX. Polyphase Systems
1. Three-phase systems; purpose and characteristics
2. Wye and delta loads
3. Wye and delta transformations
4. Three-phase power measurement

XXI. Vacuum Tubes
1. Diodes
    a. Electron emission and contact potential
    b. Characteristic curves, saturation rectification, and detection

2. Triodes
   a. Action of grid
   b. Characteristic curves
   c. Amplification factor
   d. Plate resistance
   e. Voltage amplification
3. Tetrodes and pentodes
   a. Effect of screen grid, suppressor grids
   b. Characteristic curves
   c. Use in a circuit

XXII. Power Supplies
1. Rectifier circuit
   a. Half and full wave
   b. Bridge rectifiers
   c. Metallic-oxide rectifiers
   d. Peak inverse voltage
2. Voltage multipliers
3. Filter circuits; purpose of chokes, condensors, bleeders
4. Voltage regulation
   a. Ballast tubes
   b. Electronic regulation
   c. Saturable reactors

XXIII. Amplifiers
1. Audio amplifiers
2. Distortion
3. Coupling methods
4. Feedback amplifiers
5. Power amplifiers

XXIV. Tuning Circuits
1. Series and parallel resonance circuits
2. Resonance curves
3. Selectivity

XXV. Electronic Applications
1. Block diagrams of a radio circuit
2. Block diagrams of a T.V. circuit
3. Block diagrams of photo tube circuits

LABORATORY—64 hours

Continue laboratory study as in Preparatory Physics I. Perform experiments in the following subject areas:

1. Demonstrate the mechanical advantage of various machines (suggest using compound pulleys, levers).
2. A simple pendulum. Compute theoretical period and demonstrate the effect of change on mass and length.
3. Determine the index of refraction of several transparent materials. From the index, compute the speed of light in each of the media.
4. Determine the focal length of a lens, predict the image size for various conditions, and prove results.
5. Prove the validity of the mirror equations for convex and concave mirrors. Predict the size and image for different conditions, and prove results.
6. Using the resonance principle of a known frequency, determine the speed of sound in air.
7. Determine the effects of tension and mass of a vibrating body on the determination of frequency.
8. Measure current and potentials in a series parallel circuit having two or more branches. Verify law of series circuits and parallel circuits.
9. Perform an experiment in permanent magnets to illustrate field shapes and factors affecting strength of an electromagnet.
10. Convert a D'Arsonval type galvanometer into a voltmeter of various ranges and into an ammeter of various ranges.
11. Determine characteristics of a diode.
12. Determine characteristics of a triode.
13. Experiment on series and parallel resonance.
14. Perform an experiment on cathode ray oscilloscope.

Texts and References

Backer, Bromlee and Fuller. *Elements of Physics*
Blackwood and others. *General Physics*
Dull and others. *Modern Physics*
Durbin. *Introduction to Physics*
Elliott and Wilcox. *Physics, A Modern Approach*
Greene. *Principles of Physics*
Harris and Hemmerling. *Introductory Applied Physics*
Humphreys and Beringer. *First Principles of Atomic Physics*
Olivo and Wayne. *Basic Science*
Pollack. *Applied Physics*
Stollberg & Hill. *Physics: Fundamentals and Frontiers*

PREPARATORY CHEMISTRY I AND II

HOURS REQUIRED

Class, 4; Laboratory, 4 (two semesters)

Description

This is an elementary course in chemistry equivalent to high school. It provides the necessary foundation in chemistry for students who enter: (1) a physical science technical curriculum which requires chemistry at the beginning, or (2) a technical program based on the biological sciences.

Topics and laboratory experiments are planned to teach chemistry which is related to the various chemical aspects of biological science. If the course is preparatory to chemical or metallurgical technology or other non-biological objectives, the teaching approach should emphasize inorganic chemical examples and concepts.

Laboratory exercises and experiments are designed to teach the fundamentals of chemistry and to develop chemical laboratory skills. A complete notebook for all laboratory exercises is required of each student.

For exceptional classes of students this course may be accelerated to a one-semester course by reducing the allotted time for each subject area by one-half.

	Major divisions	*Class hours*
I.	Introduction	2
II.	Measurement	6
III.	The Nature of Matter	14
IV.	Chemical Activity and Bonding	18
V.	Acids, Bases and Salts	12
VI.	Chemical Changes and Energy Transformations	8
VII.	Metals and Metal Alloys	8
VIII.	Radio-chemistry	8
IX.	Gases, Liquids and Solids	10
X.	Dispersions and Solutions	10
XI.	Organic Chemistry	18
XII.	Biochemistry	14
	Total	128

I. Introduction—Nature of Science
  1. Definition of science
  2. Scientific methods
  3. Facts, laws, hypotheses, theories
  4. Chemistry and biological science

II. Measurement
  1. Metric system
  2. Conversions
  3. Applications
    a. Density
    b. Specific gravity
    c. Heat (calories)

III. The Nature of Matter
  1. Elements
    a. Atoms and molecules
    b. Nucleus, atomic weights
    c. Electrons, protons, neutrons, isotopes
    d. Valence
    e. Radicals
  2. Compounds and mixtures
    a. Heterogeneous
    b. Homogeneous
  3. Physical and chemical changes

IV. Chemical Activity and Bonding
  1. Chemical changes
    a. Nature and causes
    b. Types of chemical changes
      (1) Combination
      (2) Decomposition
      (3) Substitution
      (4) Double replacement
      (5) Reversible reactions
  2. Writing and balancing equations

V. Acids, Bases and Salts
  1. Characteristics and properties
  2. Reactions of acids, bases, and salts
  3. Neutralization
  4. Indicators
  5. pH
  6. Buffer solutions

VI. Chemical Changes and Energy Transformations—defined
  1. Measurement of energy
  2. Chemical energy
  3. Chemical energy and electricity
  4. Energy transformations
    a. Kinetic energy to heat
    b. Electrical energy into light and heat

- VII. Metals and Metal Alloys
  - 1. General properties
    - a. Physical
    - b. Chemical
  - 2. Metallurgy
    - a. Iron and steel
      - (1) Roasting and refining
      - (2) Reduction of iron ore
    - b. Copper, aluminum
    - c. Alloys
- VIII. Radio-chemistry—radioactivity
  - 1. Radio isotopes
  - 2. Bombardment reactions
  - 3. The use of tracers
- IX. Gases, Liquids and Solids
  - 1. Kinetic molecular theory
    - a. Temperature
    - b. Pressure
  - 2. Change of state
    - a. Solid-liquid (melting-freezing)
    - b. Solid-gas (sublimation)
    - c. Liquid-gas (evaporation, boiling)
  - 3. Intermolecular forces
    - a. Cohesive; surface tension
    - b. Adhesive; capillary action
  - 4. Oxygen
  - 5. Hydrogen
- X. Dispersions and Solutions
  - 1. Mechanical suspensions
  - 2. The colloidal state
  - 3. Solutions
    - a. Solvents, solutes, solubility
    - b. Ionization and electrolysis
    - c. Osmosis
    - d. Concentration
      - (1) Percentage
      - (2) Molarity
      - (3) Normality
      - (4) Parts per million
- XI. Organic Chemistry
  - 1. Characteristics of organic compounds
  - 2. Structural formulas
    - a. Functional groups
    - b. Naming organic compounds
    - c. Reactions
      - (1) Replacement
      - (2) Addition
      - (3) Esterfication
  - 3. Relation to life sciences
    - a. Alcohols
    - b. Aldehydes
    - c. Ketones
    - d. Formaldehyde
    - e. Esters, amines
    - f. Amino acids
- XII. Biochemistry
  - 1. Lipides
    - a. Fats and fatty acids
    - b. Hydrogenation and saponification
    - c. Sterols
  - 2. Carbohydrates
    - a. Monosaccharides
    - b. Disaccharides
    - c. Polysaccharides
  - 3. Proteins
    - a. Properties
    - b. Formation
      - (1) Plants
      - (2) Animals

LABORATORY—128 hours

The following is a suggested topic outline for the laboratory sections of Preparatory Chemistry. The specific objectives under each of the first nine topics are a guide for the instructor in preparing an outline for each laboratory exercise. Following the first nine topics which are typical chemistry laboratory experiments, is a list of topics drawn from the applied field of the biological sciences. The instructor can develop from these topics, or others of his choice, laboratory experiments or demonstrations considered appropriate in developing the necessary understanding of chemistry and the required chemical laboratory skills needed by each specific group of students. The bibliography accompanying this outline lists several biological and chemical laboratory manuals in which specific chemistry experiments relating to the topics may be found.

By performing applied chemical exercises the student can become aware of the importance of chemistry and chemical analysis as a basic tool of science and also be more highly motivated to study chemistry in greater depth.

Appendix A provides an example of a developed laboratory outline for a *typical theoretical chemistry laboratory exercise* and for an *applied chemistry laboratory exercise.*

Laboratory exercises in this course should be simple and should emphasize understanding of *what* is being done, *why* it is being done, and *what the results mean*. The instructor should be imaginative in organizing successive experiments into a pattern which will meet the needs of the general curriculum's Preparatory Chemistry supports.

LABORATORY TOPIC OUTLINE

Introduction to Laboratory Equipment

1. Familiarize the student with common laboratory equipment by providing basic exercises such as using the bunsen burner, weighing, measuring, and pipetting.
2. Practice elementary glass-working by heating, bending, and cutting glass tubing.
3. Develop definite laboratory attitudes and procedures of operation by teaching the students safety rules and laboratory regulations.

Scientific Measurements

1. Acquaint the students with chemical balances and laboratory scales by assigning weighing problems using chemical reagents.
2. Make simple scientific measurements using the metric system and graduated cylinders and the millimeter ruler.
3. Develop an understanding of volume and weight relationships under the metric system by solving some specific gravity problems.

Developing Basic Laboratory Techniques

1. Perform filtration, evaporation, and precipitation operations.
2. Set up a simple glass apparatus assembly.
3. Teach the required procedure for writing laboratory reports.

Hydrogen and Oxygen

1. Acquaint the students with the nature of gasses in general through evaporation and pressure problems.
2. Study the nature of hydrogen and oxygen.
3. Provide experience in the use of complicated laboratory equipment by producing oxygen and hydrogen in the laboratory.

Properties of Solutions

1. Prepare different types of solutions used in chemical work.
2. Acquaint the student with the nature of solubility and insolubility by using various compounds and emulsions.
3. Prepare molar and normal solutions.

Indicators and pH

1. Acquaint the student with the use of various indicators for establishing pH through test materials such as solutions, soil, and other substances.
2. Test for pH in unknown materials to give the student confidence in his results.
3. Perform pH tests using an electric potentiometer.

Titration

1. Perform a titration using a typical chemical buret; emphasize exact calibration and measurement.
2. Determine the exact concentration of acids and bases in an unknown sample.
3. Practice applications of titration used in biological sciences.

Colloids

1. Study wettable powder solutions, clay suspensions, and other colloidal types of mixtures. Define the characteristics observed.
2. Demonstrate for the student how the nature of colloidal suspensions may be altered by experimental means through induction of flocculation within a colloidal suspension.

Carbon and Its Compounds

1. Demonstrate the presence of carbon in various organic materials by combustion, chemical digestion, and other chemical means.
2. Demonstrate that carbon is usually inert but can be combined with other elements when heat is applied.

Suggested Applied Chemical Laboratory Exercises

1. Test for sugar and starch
2. Alcoholic fermentation by yeasts and bacteria

3. Fat hydrolysis
4. Synthesis of starch with the aid of phosphorylase
5. Digestion of food stuffs
6. Ionic exchange of soils
7. Auxins and plant growth regulators
8. The biochemistry of milk.
9. Release of nutrients from soil materials
10. Changing of starch to sugar by enzymatic action
11. The chemistry of photosynthesis
12. The colloidal nature of protoplasm

Texts and References

Dunbar. *General Chemistry*
Francis and Morse. *Fundamentals of Chemistry and Applications*
Goostray and Schwenck. *A Textbook of Chemistry*
Hess. *Chemistry Made Simple*
Hoffman. *Chemistry for the Applied Sciences*
Neville and Newman. *Chemistry for Agricultural Students*
Read. *A Direct Entry to Organic Chemistry*
Rochow and Wilson. *General Chemistry*
Roe. *Principles of Chemistry*
Walker and others. *Chemistry and Human Health*

LABORATORY MANUALS IN CHEMISTRY

Frantz and Malm. *Chemical Principles in the Laboratory*
Goostray and Schwenck. *Experiments in Applied Chemistry*
Grillot. *Laboratory Manual for a Chemical Background in Nursing*
Hanneman. *Daily Assignment Problems in First Year Chemistry*
Holum. *Experiments in General, Organic and Biological Chemistry*
Kanda and Burtt. *Laboratory Experiments in General Chemistry*
Nitz. *A Laboratory Manual for Inductory Chemistry*
Robertson and Jacobs. *Laboratory Practice of Organic Chemistry*
Sanderson and Bennett. *A Laboratory Manual for Introduction to Chemistry*
Scarlett. *A Laboratory Manual for College Chemistry*

PREPARATORY BIOLOGICAL SCIENCE

HOURS REQUIRED

Class, 3; Laboratory, 4 (one semester)

Description

This course will acquaint the student with the fundamental concepts and phenomena underlying the biological sciences. It is designed to give the student some of the basic tools and background necessary to enter a technical curriculum based on biological sciences. After mastering this course and Preparatory Chemistry and Preparatory Mathematics, a student with no previous organized study in the sciences can reasonably expect to succeed in a biological science based technician program.

The course should be taught at a pretechnical rate and level. The primary objectives are to develop understanding of biological science fundamentals, curiosity about the science of plants and animals, and the scientific mode of thinking.

Rather than a multiple choice or prewritten laboratory report which the student completes as he gathers experimental data, a report of the *student's* own is recommended in which he states the "objective," "procedure," and "conclusions" of each experiment he conducts.

The sample laboratory outline found in Appendix B is a guide for the teacher to follow in directing the laboratory exercise. It illustrates ideas which the teacher can use to motivate the student in discovering and comprehending the results of his own experimentation and developing the data to be documented and interpreted in his laboratory reports.

One of the laboratory topics is a "student project." While only a few examples are given, it is hoped that the student will select a project which can help to identify his major areas of interest in the biological sciences.

	Major divisions	*Class hours*
I.	Biological Sciences	2
II.	The Living Cell	4
III.	General Classification Systems	2
IV.	Plant Biology	10
V.	Animal Biology	10
VI.	Growth and Reproduction	4
VII.	Bacteria	4
VIII.	Ecology	4
IX.	Basic Genetic Principle	4
X.	Applied Biological Sciences	4
	Total	48

I. The Biological Sciences
   1. Areas of study included in the biological sciences—vocations based on the biological sciences
   2. The scientific attitude—the scientific method
      a. Hypothesis
      b. Experiment
      c. Conclusion

II. The Living Cell
   1. Characteristics, structure, and functions of plant cells
   2. Characteristics, structure, and functions of animal cells

III. General Classification Systems
   1. The need for classification
   2. The general system
      a. Kingdom
      b. Phylum
      c. Subphylum
      d. Class
      e. Order
      f. Family
      g. Genus
      h. Species
   3. Comparison of a plant and animal classification (example: cat and sugar maple)

IV. Plant Biology
   1. General plant structures
      a. Leaves
         (1) Arrangements
         (2) Structure
         (3) Function
      b. Stems
         (1) Structure
         (2) Types
         (3) Internal characteristics
         (4) Functions
      c. Roots
         (1) Structure
         (2) Types
         (3) Functions
      d. Flowers
         (1) Function
         (2) Parts
         (3) Fruit
   2. Plant physiological processes
      a. Photosynthesis—the process
         (1) Requisite materials
         (2) Factors affecting the process
         (3) Importance of the process to man
      b. Respiration
         (1) The process
         (2) Chemical changes occurring
      c. Transpiration
         (1) Significance
         (2) Control

V. Animal Biology
   1. Principal divisions of phyle
   2. Generalized characteristics of each division
      a. Respiration
      b. Nutrition
      c. Excretion
      d. Circulation
      e. Skeleton
      f. Muscles
      g. Nerves
      h. Reproduction

VI. Growth and reproduction
   1. Nuclear and cell division
   2. Reproduction in plants
      a. Asexual
      b. Sexual
   3. Reproduction in animals
      a. Asexual
      b. Sexual

VII. Bacteria
   1. Structure and general characteristics
   2. Culture or cultivation
   3. Activities
      a. Fermentation
      b. Decomposition
      c. Soil relationships
      d. The nitrogen cycle
   4. Bacteria and food preservation
   5. Bacteria and disease

VIII. Ecology
   1. General factors
      a. Physical
      b. Chemical
      c. Biological
   2. The balance of nature
      a. Parasites
      b. Predators

3. Succession—return to the natural state (climax)
4. Adaptation to environmental conditions

IX. Basic Genetic Principles
   1. Heredity
      a. Mendelism
      b. The gene theory
      c. Mutations
         (1) Applications (illustrations) to plants
         (2) Applications (illustrations) to animals

X. Applied Biological Sciences
   1. Biology and agriculture
      a. Hybridization
      b. Symbiotic bacteria and legumes
      c. Growth regulators and chemical weed control
      d. Feeds and antibiotics
   2. Biology and health
      a. Diseases, causes, preventions, transmissions
      b. Water pollution and sewage
      c. Nutrition and diet
   3. Conservation of natural resources
      a. Food and world population
      b. Water supplies
      c. Wild life habitat and suburban expansion
      d. Fishery; biological resources of bodies of water

LABORATORY—64 Hours

1. The Scientific Method
   a. Perform experiments designed to develop an understanding of the scientific method.
   b. Perform an experiment having the student outline methods of approaching and researching problems including:
      (1) Preliminary observations
      (2) Hypothesis
      (3) Verification
      (4) Evaluation of data
      (5) Conclusions
   c. Provide practice in the use of the scientific method.
2. Use of the microscope.
   a. Acquaint the students with the parts of the microscope.
   b. Provide some elementary exercises using the microscope to examine biological materials.
3. The cell.
   a. Examine and diagram examples of the internal and external structure in typical plant and animal cells.
   b. Demonstrate and provide exercises in using typical slide mounts.
4. Protoplasm.
   a. Demonstrate the nature and place of protoplasm in plant and animal life.
   b. Examine and report the significant information about protoplasm found in such materials as Elodes and the Amoeba.
5. The phenomenon of photosynthesis
   a. Acquaint the student with the phenomenon of food manufacture in the higher order plants.
   b. Illustrate and explain the importance of chlorophyll to man and animals.
   c. Demonstrate proof of photosynthetic food manufacture by starch test.
6. The fundamentals of the process of photosynthesis.
   a. Demonstrate the importance of CO_2, light, and water and their relationship to food production in plants.
   b. Prove by experimentation that photosynthesis cannot occur if one or more of the essential factors is lacking (Law of Limiting Factors).
7. Respiration
   a. Demonstrate the process of respiration in plants and animals.
   b. Demonstrate by simple experiments the difference between aerobic and anaerobic respiration and the relationship of each to fermentation.
   c. Demonstrate the relationship of aerobic and anaerobic respiration to food spoilage and preservation.
8. Osmosis and permability
   a. Demonstrate osmosis.
   b. Prepare and label a diagram of the experiment.

9. Cell plasmolysis
    a. Make simple experiments and demonstrations to illustrate cell plasmolysis.
    b. Relate this phenomenon to the life science field through appropriate examples and illustrations.
10. Enzymes
    a. Illustrate the place of enzymes in the metabolic processes of plants and animals.
    b. Perform simple experiments such as the reaction of the digestive enzyme (ptyalin) in changing starch to sugar or how fat or protein substances are digested with appropriate enzymes.
11. Demonstrate the effect of hormones on living organisms through simple experiments with plants.
12. Bacteria
    a. Illustrate the characteristics of bacterial life.
    b. Make a bacterial culture and study it under the microscope. Draw and label bacterial growths.
    c. Prepare a simple slide smear and employ the staining and fixing processes.
13. A biological field trip
    a. Demonstrate, through observation and contact, the varying characteristics of plant and animal life as they occur in the field.
    b. Illustrate the necessity of having a classification system.
14. Conservation of natural resources
    a. Visit suburban or rural areas and observe evidence of soil erosion and water loss.
    b. Provide students with an opportunity to hear a wild life specialist discuss problems related to the conservation of wildlife.
15. A biological specimen collection; preparing the collection with appropriate identification of all specimens. Examples:
    a. Insects
    b. Leaves, buds, and twigs
    c. Plant census within a limited boundary
16. Nutritional experiments with laboratory animals

Texts and References

Beaver. *Workbook and Laboratory Manual in General Biology*
———. *General Biology: The Science of Biology*
Dillon and Cooper. *A Laboratory Survey of Biology*
Downes. *The Chemistry of Living Cells*
Foth and Jacobs. *Laboratory Manual for Introductory Soil Science*
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Wald and others. *Twenty-six Afternoons of Biology, An Introductory Laboratory Manual*
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APPENDIX A

Examples of Chemistry Laboratory Exercises in Preparatory Chemistry for Biological Science Based Curriculums

I. IONIC EXCHANGE IN SOIL

Preliminary Explanations: The student should understand that:

1. The presence of hydrogen ions (H^+) is the primary cause of soil acidity.
2. The clay particles of soil are negatively charged (—) and, therefore, can hold on to and attract positively charged ions ($^+$) such as potassium (k^+), calcium (Ca^{++}), or hydrogen (H^+).
3. Dumping many positive charged ions ($^+$) such as Ca^{++} into a soil can replace many of the acid causing H^+ ions (Cation Exchange).
4. In this particular experiment, we replace the H^+ with K^+ ions.

Objectives:

1. To demonstrate how limestone changes an acid soil to a more alkaline soil.
2. To develop an understanding of the exchange of plant nutrient elements that occur in the soil (Cation Exchange) to specifically show how hydrogen ions (H^+) held on the clay particles can be exchanged or replaced by other ions; the direct application is the liming of soils.

Materials needed:

1. Acid soil (subsoil in large container)
2. Funnel rack and stand
3. Two funnels
4. Two beakers
5. Filter paper
6. Distilled water
7. 1/10 solution of potassium nitrate
8. Chlor-phenol red solution from a pH testing kit

Procedure:

1. Secure funnel rack to stand.
2. Place filter paper in each funnel and fill them with soil.
3. Place a beaker under each funnel to catch the leachate.
4. Leach the soil in one funnel with potassium nitrate and the soil in the other funnel with distilled water.
5. Continue leaching until each beaker is about ¼ full.
6. Add chlor-phenol red to each beaker, 2 - 4 drops should be sufficient.
7. Observe any changes in color that occur.

NOTE: The distilled water which is neutral should flow through the soil unchanged and be purple when the chlor-phenol red is added. The potassium of the potassium nitrate solution should replace the H^+ ions causing them to be found in the filtrate. This solution should then be turned a shade of orange to yellow due to the presence of the H^+ ions. (If tap water is contaminated, the experiment will not work because of the presence of calcium and other minerals.)

Applications:

1. We use limestone to sweeten a soil because it contains Ca^{++} ions which are capable of replacing the H^+ ions responsible for the acid condition. (Limestone is also used because it is plentiful and cheap.)
2. If it is primarily the clay particles which hold the H^+ ions causing the acidity, this explains why Experiment Stations recommend more lime be applied to soil high in

clay than to sandy soil with the same pH reading but lower in clay content.

NOTE: Be sure all glassware in this experiment is rinsed with distilled water before starting. The presence of hard water mineral accumulation will cause this experiment *not* to work.

2. PROPERTIES OF SOLUTIONS

Objectives:

1. To acquaint the student with the characteristics of different types of solutions.
2. To acquaint the student with the nature of solubility and insolubility.
3. To acquaint the student with the concepts of normality and molarity.

Related information:

A. Definitions:
   1. Solvent — substance (usually liquid) in which another dissolves in varying quantities. The common or universal solvent is water.
   2. Solute—the substance dissolved in a solvent.
   3. Saturation—the point at which no more solute will dissolve under the existing temperature and pressure.
   4. Supersaturation—solutions containing more than usual saturated amounts of a solute.
   5. Normal solution—a solution containing 1 gram of replaceable hydrogen or 17 grams of hydroxyl radical per liter of solution.
   6. Molar solution—a solution containing 1 gram molecular weight of a solute per liter of solution.
   7. Hydroxyl radical—the —OH radical found in bases, alkalis, or water.

B. General characteristics of water solutions:
   1. Solutes vary in their solubility in water.
   2. Substances which do not dissolve a great deal are usually called insoluble.
   3. Raising the temperature of the solvent usually increases the solubility—there are exceptions to this, however.
   4. Saturated solutions at high temperatures may not crystallize out when cooled unless disturbed — these solutions are called "supersaturated" solutions.

C. Expressing solution concentration:
   1. Percentage—by weight of the solute in the solution; study carefully the illustrations given by your instructor.
   2. Molarity—a molar solution is a means of expressing the number of gram molecular weights of solute in one liter of solution. These are referred to as 1M, 2M, etc.
   3. Normality—a means of expressing the number of gram equivalent weights in a liter of solution. These are referred to as 1N, 2N, 3N, etc.
   4. Acids and bases are often referred to as being N or M solutions.

D. Solubilities of some common compounds in water at room temperature:

Solute	*g dissolving in 100 ml of water*
Barium carbonate	.0022
Barium chloride	35.2
Barium hydroxide	3.7
Barium iodide	201.36
Calcium bromide	143.0
Calcium carbonate	.0013
Calcium chloride	72.0
Calcium hydroxide	.17
Calcium iodide	202.8
Calcium nitrate	125.8
Calcium sulfate	.20
Lead chloride	1.49
Lead iodide	.08
Lead sulfate	.0041
Magnesium carbonate	.10
Magnesium chloride	56.0
Magnesium hydroxide	.001
Magnesium sulfate	35.2
Potassium carbonate	111.0
Potassium chlorate	6.6
Potassium chloride	33.9
Potassium hydroxide	110.0
Potassium nitrate	29.6
Potassium sulfate	11.1
Silver chlorate	12.25
Silver chloride	.00015

Solute	*g dissolving in 100 ml of water*
Silver iodide	.00000035
Silver nitrate	211.6
Silver sulfate	.58
Sodium carbonate	19.3
Sodium chlorate	97.16
Sodium chloride	35.9
Sodium fluoride	4.49
Sodium hydroxide	107.5
Sodium iodide	177.9
Sodium nitrate	86.1
Sodium sulfate	16.83
Zinc hydroxide	.0004
Zinc nitrate	115.0
Zinc sulfate	55.6

Part I—Solutions, solutes, and solvents

Directions

A. Soluble and insoluble substances:

1. Place 1 g each of $CaCO_3$, $CaSO_4$, NaCl, KnO_3, and $NaNO_3$ in separate clean, dry, large test tubes.
2. Add water until test tubes are about ½ full.
3. Stopper test tubes and shake each vigorously.
4. Examine the solutions in the test tubes carefully.
5. List solutes in order from least soluble to most soluble.
   (1)
   (2)
   (3)
   (4)
   (5)
6. Check your results with the solubility table supplied.
7. Which substances would you call insoluble?

B. Solvents:

1. Place 1 g of NaCl in each of 3 clean test tubes.
2. Add 2 ml of alcohol to one of these test tubes, 2 ml of water to one, and 2 ml of diluted HCl to the 3rd.
3. Stopper test tubes and shake vigorously.
4. Allow to settle and observe test tubes.
5. How do these solvents vary in their ability to dissolve salt? List in order of amounts dissolved.

C. Temperature and solubility:

1. Place 1 g of NaCl in a large test tube.
2. Add 2 ml of water.
3. Heat to boiling.
4. Allow excess salt to settle.
5. Decant supernatant liquid into another test tube.
6. Cool 2nd test tube slowly in cold running water.
7. How is the solubility of NaCl affected by increased temperature? ....
   ....
8. Repeat the steps above using $KClO_3$ instead of salt.
9. Record the results this time. ....
   ....
10. Which becomes soluble to a greater degree when heated NaCl or $KClO_3$? ...
    ....

Part II—Supersaturation

A. Supersaturated solution of sodium thiosulfate:

1. Place 1 g of sodium thiosulfate in a large test tube.
2. Add 1 drop of H_2O, no more.
3. Heat gently until solid melts—keep warm for 2 or 3 minutes.
4. Set aside to cool—*do not jar or move unnecessarily.*
5. After 10 minutes inspect the solution — has it recrystallized? ....
6. Add a tiny crystal of sodium thiosulfate What happens? ....
   ....

NOTE: If crystallization has occurred in step 5, you should repeat.

B. Temperature changes with supersaturated solutions:

1. Place 1 g of sodium in a small flask
2. Add 4 drops of water.
3. Heat gently to the boiling point.
4. Plug the top with absorbent cotton.
5. Set aside to cool in room temperature.
6. Insert a thermometer into the solution in flask.

7. Drop a small crystal of sodium acetate into solution.
8. What happens to the temperature?.....
....
9. What happens to the sodium acetate?....
....
10. Was this a chemical or physical change?
....
11. Explain the reaction occurring. ....
....

Reference: *Introductory Chemistry*, Meyer; pp. 164-184.

I. Complete the following table:

Compound	Common Name	*Weight in a liter of normal solution*	*Weight in a liter of molar solution*	*Amount which will dissolve in a liter*
$KClO_3$				
$Ca(OH)_2$				
NaCl				

II. What weight of barium hydroxide is present in a 2N solution?

III. What weight of anhydrous ferrous sulfate ($FeSo_4$) is present in 100 ml of 2N ferrous sulfate solution?

IV. What bearing does a knowledge of solutions have upon our understanding of the digestive process?

V. What is meant by the agricultural term "Hydroponics" and what relationship does it bear to the study of solutions?

VI. What interest does the dairy manufacturer have in the strength of solutions and crystallization?

VII. What is meant by the homogeneity of a solution?

APPENDIX B

A Typical Laboratory Experiment for Preparatory Biological Science

1. CELL PLASMOLYSIS

Objectives:

1. To provide a basic experiment which will illustrate the phenomenon of cell plasmolysis.
2. To provide an experiment which will require the student to prepare and use a simple microscope slide, adjust and use the microscope.
3. To provide an opportunity for the student to independently study a reaction and draw conclusions.

Materials:

1. Plant material—Zebrina Pendula
2. Compound microscope
3. 0.25 M sucrose solution
4. Slide mount materials
5. Distilled or demineralized water

Procedure:

1. Strip away some of the epidermis covering the midrib on the lower surface of the leaf of Zebrina Pendula (Wandering Jew).
2. Mount this epidermal specimen in water and examine under the microscope. Make a simple drawing of what the cells look like and label as "normal."
3. Replace the water with 0.25 M sucrose solution and allow to stand for several minutes.
   a. Observe the slide mount periodically.
   b. Make another drawing of what the cells look like and label them as "plasmolyzed."
4. Again, replace the sucrose solution with distilled water—if no change, repeat with freshly plasmolyzed cells.

Conclusion:

1. Explain the phenomenon of plasmolysis in your own words.
2. What moved out of the cells when they became plasmolyzed?
3. What evidence can you provide to support the above conclusion?

Applications:

1. What are some applications to everyday life science occurrences where plasmolysis might play a part?
2. What beneficial effects of plasmolysis can you think of? Detrimental effects?

APPENDIX C

Audiovisual Materials and References

I. SOME SELECTED SOURCES OF AUDIOVISUAL MATERIALS

Addison-Wesley Publishing Co.
Department EB201
Reading, Massachusetts 01867

California Test Bureau
206 Bridge Street
New Cumberland, Pa. 17070

Central Scientific Company
1700 Irving Park Road
Chicago, Illinois 60613

Coronet Instructional Films
65 E. South Water Street
Chicago, Illinois 60601

Doubleday and Company
Garden City
New York 11530

George Vincent McMahon
Electronic Engineering
Research & Development Labs
381 West 7th Street
San Pedro, California 90731

Encyclopaedia Britannica Inc.
425 North Michigan Avenue
Chicago, Illinois 60611

Ginn & Company
717 Miami Circle, N. E.
Atlanta, Georgia 30324

Graflex, Inc.
Programmed Learning Dept.
P.O. Box 101
Rochester, New York 14061

Harcourt, Brace & World, Inc.
Dept. of Programmed Instruction
757 Third Avenue
New York, New York 10017

Inrad
P.O. Box 4455
Lubbock, Texas 79409

Lyons and Carnahan
407 East 25th Street
Chicago, Illinois 60616

McGraw-Hill Book Company, Inc.
350 West 42nd Street
New York, New York 10036

The Macmillan Company
60 Fifth Avenue
New York, New York 10011

Prentice-Hall, Inc.
Englewood Cliffs
New Jersey 07632

The Psychological Corporation
304 East 45th Street
New York, New York 10017

J. Ravin Publications
4215 Calevo Drive
LeMesa, California 92041

Science Research Associates, Inc.
259 East Erie Street
Chicago, Illinois 60611

Tarmac Audio Visual Co.
71 North Market
Asheville, North Carolina 28801

Teaching Materials Corporation
575 Lexington Avenue
New York, New York 10022

Training Systems, Inc.
12248 Santa Monica Boulevard
Los Angeles, California 90025

Tor Education, Inc.
55 Fifth Avenue
New York, New York 10003

Universal Electronics Labs. Corp.
510 Hudson Street
Hackensack, New Jersey 07601

2. SOME SELECTED REFERENCES DEALING WITH AUDIOVISUAL TEACHING

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